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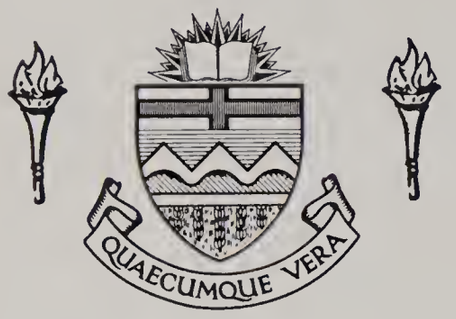

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BREEDING BEHAVIOUR OF WHITE PELICANS IN THE BIRCH MOUNTAINS, NORTHEASTERN ALBERTA

by

© Rick Darryl Beaver

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND

RESEARCH IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF MASTER OF SCIENCE

IN THE

DEPARTMENT OF ZOOLOGY

EDMONTON, ALBERTA

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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Breeding Behaviour of White Pelicans in the Birch Mountains, Northeastern Alberta", submitted by Rick Darryl Beaver in partial fulfillment of the requirements for the degree of Master of Science.

To Lizzanne ..... continuing interest and involvement with things wild and free. Your contribution, with patience and encouragement through hours of enjoyable discussions has found its way into many of the pages which follow. Thank you.

ABSTRACT

A study of behaviour was conducted on a population of White Pelicans (Pelecanus erythrorhynchos) in the Birch Mountains area of northeastern Alberta during the 1976 and 1977 breeding seasons. Patterns of behaviour were documented and described for the entire period from spring arrival to the birds' departure which commenced in early September.

In both years, pelicans established nesting colonies on a small island in an unnamed lake located approximately 10 km south of Namur Lake. White Pelicans arrived at the breeding grounds as early as late April before ice had left the majority of water bodies and commenced courtship and mating activities immediately after ice had melted from the breeding site in early May. Protracted spring arrival was indicated, however, with maximum numbers of adults observed at the rookery in late May and early June.

Behavioural interactions among adults were most frequent during courtship and mating and declined thereafter. Synchronous groups of courting birds formed the nuclei of colonies which subsequently formed over a period of from 2 to 4 weeks. Individual colonies were formed over a period of from 7 to 14 days and were composed of from 4 to 70 breeding pairs. Varying degrees of reproductive synchrony were noted among colonies.

A detailed discussion of behaviours observed, their patterning throughout the reproductive season and comparison to those of other pelican species is presented.

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INTRODUCTION

Ten traditional nesting areas (termed rookeries, after Taylor (1962)) of White Pelicans (Pelecanus erythrorhynchos) Gmelin have been abandoned in recent decades in Alberta (Markham 1978). Human encroachment upon the island breeding sites preferred by this species, coupled with the destruction of breeding ground habitat, have been the two most important factors cited in the local population declines recorded in North America during this time (Farley 1919; Behle 1935; Low, Kay and Rasmussen 1950; Marshall and Giles 1953; Hosford 1965; Sanderson 1966; Anderson and Bartonek 1967; Vermeer 1969, 1970).

Historic information on the White Pelican colonies (colonies are defined after Taylor (1962) as spatially distinct nesting areas within the rookery) at Alberta's Namur Lake (Figure 1) is scant. It is known that in the period from 1967 to 1969, as many as 153 breeding pairs per year occupied a small forested island in the northeast end of the lake (Vermeer 1970). In 1974, 198 breeding pairs of White Pelicans occupied this site (letter dated 18 October 1976 from A.B. Rippin, Regional Wildlife Biologist, St. Paul, Alberta). White Pelicans initiated nesting at Namur Lake in 1975 but deserted their nests when disturbed by local fishermen (conversation in August 1975 with Mr. A. Smith, Canadian Wildlife Service employee, Edmonton, Alberta). An aerial surveillance of the Namur Lake site on 25 July 1975 confirmed the reported abandonment of the rookery. Subsequently, I observed 12 young White Pelicans on Big Island Lake (local name), located approximately 20 km northeast of the Namur Lake site. It is suspected that this sighting signified a renesting

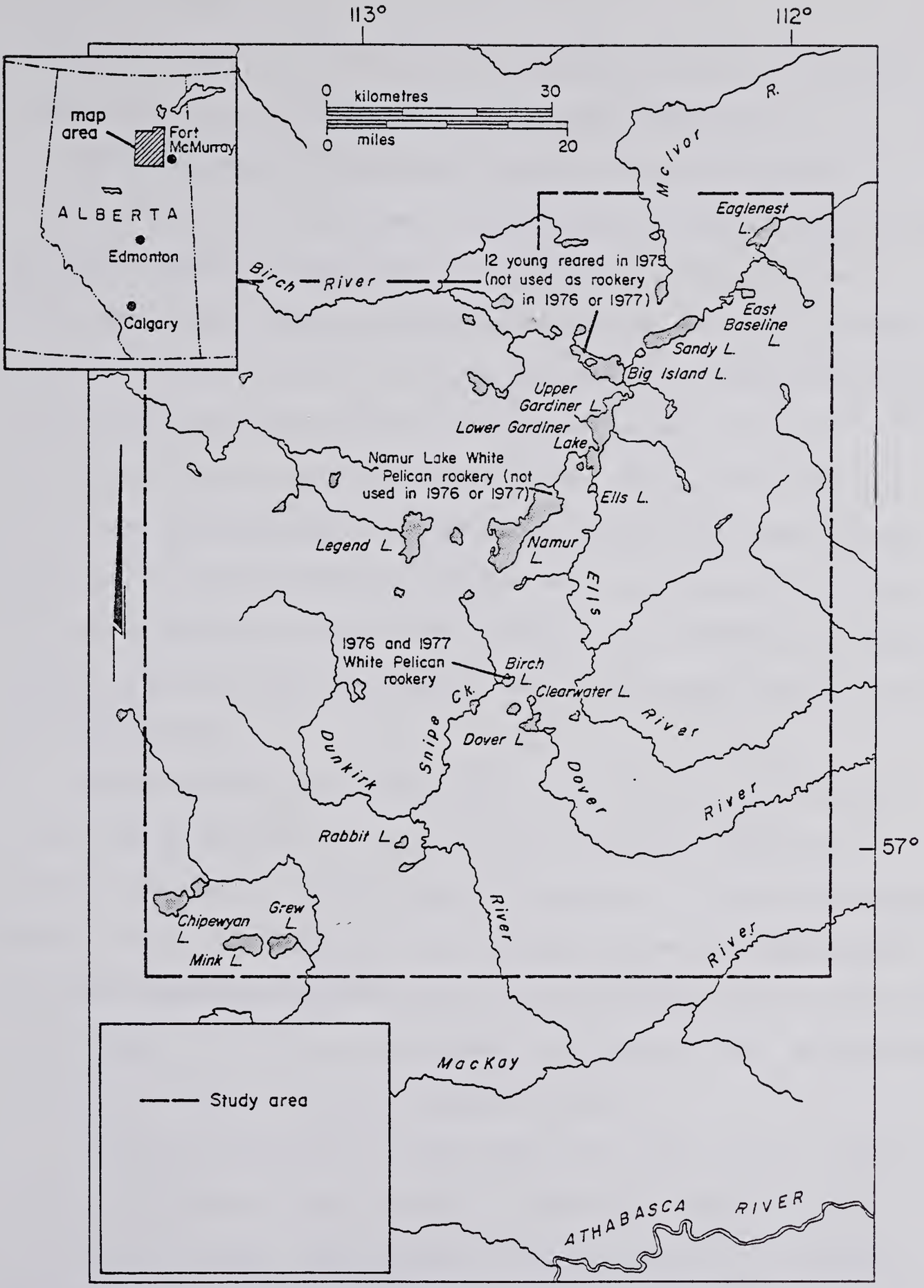


Figure 1. Location of the White Pelican project study area in northeastern Alberta.

attempt by some of the Namur Lake birds and not an entirely different rookery, but this interpretation could not be substantiated.

White Pelicans were observed foraging in the Gardiner Lakes narrows in 1974 and in the Lower and Upper Gardiner Lakes proper in 1975 and 1976 (telephone conversation in September 1976 with Cort Sims, Department of Anthropology, University of Alberta, Edmonton, Alberta). On 25 July 1975, a total of 111 White Pelicans were sighted on Mink and Grew Lakes, approximately 65 km southwest of the Namur Lake site. Fifty more pelicans were sighted on the site of the 1976 and 1977 rookery at Birch Lake (assigned name), located approximately 15 km south of Namur Lake, but it was not determined whether the birds were nesting. White Pelicans continued to forage in the Gardiner Lakes in 1977 and foraging activity was also noted on Eaglenest, Mink, Grew and Big Island Lakes in 1977 (Ealey 1979).

Acknowledgement that human visitation during the nesting season could lead to reproductive failure of White Pelicans prompted the Province of Alberta to adopt protective measures. In view of accelerated human use of the Athabasca oil sands deposits and an existing lack of knowledge regarding the behavioural responses of White Pelicans to various disturbances, initiation of this study was proposed in 1975 as part of the Alberta Oil Sands Environmental Research Program.

The general objectives of this study were to describe the breeding status of the White Pelican in the oil sands area, to provide basic information to assess the potential effect of industrial development and related activities on this species, and to provide guidelines for

habitat reclamation. These topics have been addressed in a separate report prepared for the Alberta Oil Sands Environmental Research Program (Beaver and Ballantyne 1979). The present thesis, however, will be concerned with a detailed discussion of behaviour with emphasis on aspects not well documented by others.

The specific objectives of the behavioural study were as follows:

1. To determine the chronology of reproductive events for White Pelicans breeding in northeastern Alberta.
2. To describe the reproductive behaviour pattern throughout the period from the birds' arrival in spring to their departure in autumn.
3. To investigate and describe the physical and behavioural changes of both adults and their young throughout the spring and summer months.
4. To determine temporal movement patterns associated with foraging.
5. To compare the findings of this study with those of other researchers involved in investigations of the behaviour of the Pelecanidae.

LITERATURE REVIEW

In addition to the brief summary of previous investigations conducted in the Birch Mountains area presented in the introduction, a more thorough literature search of pertinent topics was conducted. All available literature concerning the behaviour of the White Pelican and other pelican species has been reviewed and is briefly summarized below.

Published literature concerned with detailed research on biology and behaviour of White Pelicans is rather sparse. Much of the information is derived from casual observation and general notes on occurrence, food habits, breeding grounds, reproductive status and disturbance of breeding colonies. For reasons of thoroughness, unpublished references were also investigated; where relevant, these references have been cited in text. This literature review may be of some assistance to further investigations of the biology of the Pelecanidae in general.

RESEARCH ON BEHAVIOUR

White Pelican (Pelecanus erythrorhynchos)

Bartholomew, Dawson and O'Neill (1953) investigated the thermoregulatory behaviours of young and adults at a rookery in California's Salton Sea. They suggested the importance of cooling adaptations in this hot arid climate and presented evidence of the effectiveness of behaviours such as "panting," "bill-plunging," "shade seeking" and "bathing" in controlling body temperatures.

Schaller (1964) conducted the earliest detailed study of the breeding behaviour of the White Pelican at Wyoming's Yellowstone Lake. Notable in this paper were the sections dealing with behaviour patterns over most of the reproductive season. Physical and behavioural development of young birds were also discussed. Schaller's discussion of synchronized nesting within the colonies he observed and an outline of the reproductive chronologies in general have been referred to in more recent works on other pelican species.

Knopf (1975a) further investigated synchronized colonial nesting habits of the White Pelican at Gunnison Island in Utah's Great Salt Lake. His discussion of spatial and temporal aspects of colonial nesting of White Pelicans focused on the reproductive success of nesting birds distributed within the colonies at various times throughout the breeding season. Descriptions of breeding behaviour patterns and plumage phenologies of adults were presented as well.

Brown Pelican (Pelecanus occidentalis) Linnaeus

The most comprehensive study of the breeding behaviour of this species throughout the entire reproductive season was conducted by Schreiber (1977) in Florida. He monitored the activities of a tree-nesting rookery there, providing detailed discussions of behaviour postures, behaviour changes throughout the season and attempted to analyze the function of certain behaviours. Descriptions and illustrations of both maintenance and communication behaviours were found invaluable for comparison with other works.

Eastern White Pelican (Pelecanus onocrotalus) Linnaeus

The first treatment of behaviour of this species in Africa was undertaken by Feely (1962). His observations, though not as detailed as subsequent investigations, provided a framework for following work. Descriptions of nuptial plumages, sexual dimorphism and behaviour displays indicated similarities with other pelican species. A brief mention of nesting synchrony was included.

Brown and Urban (1969) continued investigations of the biology and behaviour of the Great White Pelican (P. onocrotalus roseus), a race inhabiting Africa south of the Sahara Desert. Their work on breeding plumages, behaviour, foraging movements and development of the young was valuable in considering similarities with other pelican species. Additional observations were provided by Brown, Powell-Cotton and Hopcraft (1973) who gave details of nesting synchrony for several colonies of the Great White Pelican in east Africa. The latter authors also presented additional behavioural information for the species.

Pink-backed Pelican (Pelecanus rufescens) Gmelin

Detailed behavioural study of this tree-nesting African species was conducted by Burke and Brown (1970). Data on daily movement patterns to and from foraging areas, feeding schedules of young, breeding behaviour and nesting synchrony were presented. Description of plumage characteristics and breeding chronologies were complete for the entire reproductive season. Interactions between adults and young were also investigated.

Australian Pelican (Pelecanus conspicillatus) Temminck

Work by Vestjens (1977) on this Australian species was similar to investigations by other pelican researchers, detailing behaviours, reproductive chronologies and plumage descriptions. Noteworthy was the absence of any indication of the degree of synchrony of colonial nesting in this species although the author's description of reproductive chronologies suggest that some synchrony occurred.

The various terms used for behavioural patterns throughout these papers made an attempt at delineating homologies difficult. Van Tets (1965) did include discussions of the evolutionary origins and derivations of behavioural postures in his presentation; however, as he acknowledged, much more behaviour work is necessary on the seven extant members of the Pelecanidae before definitive homologies could be determined. In fact, details of behavioural descriptions on two extant species, the Dalmatian Pelican (Pelecanus crispus) Bruch of Eurasia and the Gray Pelican (Pelcanus philippensis) Gmelin were not found in the literature.

THE STUDY AREA

LOCATION AND DESCRIPTION

The Birch Mountains area is comprised of a series of uplifted hills ranging from 610 to 870 m above sea level (asl). In the White Pelican project study area (Figure 1) from north to south, eleveations decrease from 870 to 460 m asl. Within this area are found the headwaters of the Birch, Mikkwa, Dunkirk and Ells Rivers. The Mikkwa and Ells Rivers originate from larger lakes in the Birch Mountains: the Mikkwa, from Legend Lake, drains northwest into the Peace River; the Ells, from the Gardiner Lakes, flows south then east to the Athabasca River.

Rowe (1972) includes the Birch Mountains area in the boreal mixedwood forest region. Mixed forests of Trembling Aspen (Populus tremuloides), White Birch (Betula papyrifera) and White Spruce (Picea glauca) grow on the better drained slopes and uplands. Black Spruce (Picea mariana) dominates the forest cover in the more poorly drained areas. Jack pine (Pinus banksiana) enters into the forest cover on drier sandy or till soils but is not extensive. Sparsely forested shrub-dominated communities are found on the highest elevations in the northeast corner of the study area and also occur over recently burned landscapes.

Attention has been focused on two areas within the larger project study area. The first, at Birch Lake (local name) is located in the Snipe Creek drainage basin at an elevation of approximately 530 m asl. The second includes the lake complex forming the headwaters of the Ells

River and includes Namur, Gardiner, Big Island (local name) and Eaglenest Lakes, as well as several other unnamed lakes. These lakes are located at higher elevations, approximately 720 m asl.

Birch Lake, covering an area of approximately 1.7 km^2, is a relatively shallow eutrophic lake which does not exceed 6 m in depth. Located between an abrupt rise in the Birch Mountains to the north and more gradual surrounding relief, the lake is characterized by extensive littoral and marsh vegetation zones. The headwater lakes of the Ells River, by contrast, are surrounded by large hills rising to 100 m above lake levels. The shorelines of these lakes have relatively less expansive littoral zones; emergent vegetation, if not entirely absent, is restricted to a few locations. Available sounding information indicates much deeper basins in these lakes, varying from 15 to 60 m (Turner 1968).

MATERIALS AND METHODS

The major activities in this study were aerial censusing and behaviour observations at the Birch Lake rookery.

DISTRIBUTION SURVEYS

An aerial census was flown on 26 April 1977 employing a Cessna 185 float-equipped aircraft with one observer present. Survey altitudes varied from 100 to 200 m above ground level (agl) at flying speeds of 100 to 150 km/h. Forty-eight lakes and two major flowing watercourses were censused for White Pelicans. Larger lakes were surveyed by following shoreline and transects while shoreline circuits gave adequate coverage of smaller lakes.

The survey was flown to determine the arrival date of the pelicans and whether the birds assembled on waters first freed on winter ice cover. White Pelicans have been sighted at rookery sites before spring ice had melted at Lavallée Lake in Saskatchewan (conversation in September 1976 with Mr. H. Armbruster, Canadian Wildlife Service employee, Edmonton, Alberta) and also at Pelican Lake in Manitoba (Anderson and Bartonek 1967).

All waterbodies were classified as being frozen, partially ice-free or ice-free. Numbers of White Pelicans observed at such waterbodies were recorded.

Intensive surveys of waterbodies within the project study area were similarly conducted on 27 and 28 May, 14 and 17 June, 23 August and 15 September in 1976. These surveys were repeated in 1977 on 26 April, 6

May, 8 June, 11 July, 13 and 16 August and 10 September. These surveys collectively enabled a determination of the extent of the foraging range of White Pelicans in the area surrounding the rookery.

BREEDING POPULATION CENSUS

The breeding population was determined by estimating the number of occupied nests during the peak nesting period and multiplying this figure by two (Lies and Behle 1966; Vermeer 1970; Boeker 1972). I chose to census aerially as described by Boeker (1972) rather than by direct visitation to the island; the latter technique could have panicked the incubating adults, incurring damage to nest contents by their flushing or leaving eggs or young exposed to the elements or the predatory habits of California Gulls (Larus californicus) (Schaller 1964; Vermeer 1968; Johnson 1976; Johnson and Sloan 1976). At Birch Lake, there were approximately 15 and 25 pairs of California Gulls nesting in association with the pelicans in 1976 and 1977 respectively.

Observations of the rookery at Birch Lake indicated peaks in nesting activity during mid-May in 1976 and early June in 1977. Based on the observation that nest relief occurs at midday during incubation (Schaller 1964; Knopf 1975a), the surveys were flown at 0900 to avoid enumerating loafing birds that were not on nests. These censuses were conducted on 27 May 1976 and 8 June 1977.

The nest count estimates assumed that all birds counted were on nests and were therefore breeding. Birds observed either in the air or on the water in the photographs obtained were not enumerated. Both 55 mm and

200 mm lenses, mounted on a 35 mm single-lens reflex camera, were employed for photographing the colonies. Pictures were taken at elevations of 600, 450 and 300 m above the rookery.

BEHAVIOUR OBSERVATION

A field camp was erected on the east shore of Birch Lake on 20 June 1976. A stationary observation blind, consisting of a platform 1 m above the water, was constructed on the tip of a sedge (*Carex* spp.) and willow (*Salix* spp.) point of the northeast shore, approximately 300 m from the rookery. Observations were conducted with the aid of either 10 x 50 power binoculars or a 15-60 variable power spotting scope. Two observers each watched for two 2-hour long periods daily, weather permitting. On alternate days, the observation periods were shifted resulting in data collection for all hours between sunrise and sunset. Travel to and from the blind was by canoe. A camouflaged floating blind was used in 1977 to permit detailed observation of the rookery at closer ranges. Three visits were made to the rookery in this apparatus in 1977 during the courtship, incubation and brooding phases of the reproductive cycle.

During windy or inclement weather when travel on the lake was restricted, observations were conducted from a hill on the east shore of Birch Lake, using the spotting scope. From the hill visibility was inadequate to allow viewing of the entire rookery and the number of detailed behaviour observations was reduced additionally by the distance (800 m) involved and heat distortion over the water. Logistic support

to the field camp was by Hughes 500-C jet helicopter during the period until brooding had begun to wane; thereafter, a float equipped Cessna 185 aircraft was used.

I noted the dates of commencement of courtship, nest construction and defense, incubation and hatching for breeding White Pelicans, as well as the date of cessation of continuous brooding. Development of growth and behaviour for maturing young were also recorded from the stationary and floating blinds. Dates of dispersal were inferred from reductions in the number of adults and/or young remaining at the rookery later in the year.

In 1977 only, 12 nests were selected to monitor the nest relief frequencies of specific incubating or brooding pairs by observing them continuously during the daylight hours on consecutive days. All nests were visible from the permanent observation blind. Female and male members of each pair occupying a nest were identified by combinations of the following distinguishing features (Knopf 1975b):

1. Males are generally larger than females.
2. Bills of females are shorter than those of males.
3. Individual differences in the extent and patterning of the presupplemental moult of the head region are evident.

The presence of bright orange feet and bill, one or occasionally two or three upper maxillary protruberances (horns) and pale yellow or white crest plumes was used to distinguish sexually mature birds from sub-adults (Knopf 1975b) which possessed drabber colouration of the bill and feet, grayer plumage, and lacked plumes or horns.

Nest relief ceremonies and duration of the components of nest relief ceremonies were documented for male and female members of the pair during incubation and brooding.

A record was also kept of the number of adults arriving at or departing from the rookery during the hours of observation. The number and direction of motion of flocks and their size were also noted. Rates of egress and ingress of adults were examined contemporaneously with hourly counts of the number of nest reliefs and feedings of young with which such movements appeared to be associated.

Several methods of recording behaviour were used. During periodic intensive 10-minute observation periods, a record was kept of behaviours of individual loafing, incubating or brooding birds. During other 5-minute periods, the incidence of a single behaviour for all birds present was noted. Incidental, more general notes, provided additional information on the occurrence of various activities during different stages of the reproductive cycle. Thus, the calculation of the occurrence of all behaviour was facilitated throughout the breeding season, with the provision for checks of the rates of occurrence of specific behaviours by means of the more detailed, intensive observation periods which considered the number of birds present during counts. The pelican-minute unit employed in the analysis of rates referred to one pelican observed for 1 minute. A hand held stopwatch was used to time the duration of nest relief ceremonies and the activity periods of individuals observed intensively. Additionally, air temperature readings (in ^{o}C) were recorded daily, prior to each period of observation, from a thermometer

situated in shade approximately 1.6 m above ground at the field camp on the east shore of Birch Lake.

Weather and time permitting, an effort was made to spread hours of observation evenly over the hours of the day from 0400 to 2200 during successive weekly periods. A late field season start in 1976 precluded the collection of data on earlier reproductive events, but information was obtained for the period from 23 June to 11 September which covered the brooding through dispersal phases of the reproductive cycle. In 1976, 226 hours of observation were accumulated. A mean of 17.4 hours (range: from 4.8 to 37.8) was devoted to each weekly period. A mean of 12.6 hours (range: from 2.5 to 31.6) was devoted to each hourly period of the day over the period studied.

In 1977, a total of 355 hours of observation were conducted in the period from 3 May to 5 September. The earlier field season start enabled coverage of the entire sequence of events from arrival of the population to departure of the birds from the rookery in the fall. A mean of 19.7 hours (range: from 2.5 to 37.0) was devoted to each weekly period during this time. A mean of 19.7 hours (range: from 2.5 to 37.0) was devoted to each hourly period of the day over the study period.

ROOKERY INVESTIGATION

Direct visits to the rookery were made on 1 August 1976 and 19 August 1977 for the purpose of measuring the extent of the island, determining nesting substrate and degree of vegetative cover. In 1977, a carcass count of dead young was also conducted.

RESULTS AND DISCUSSION

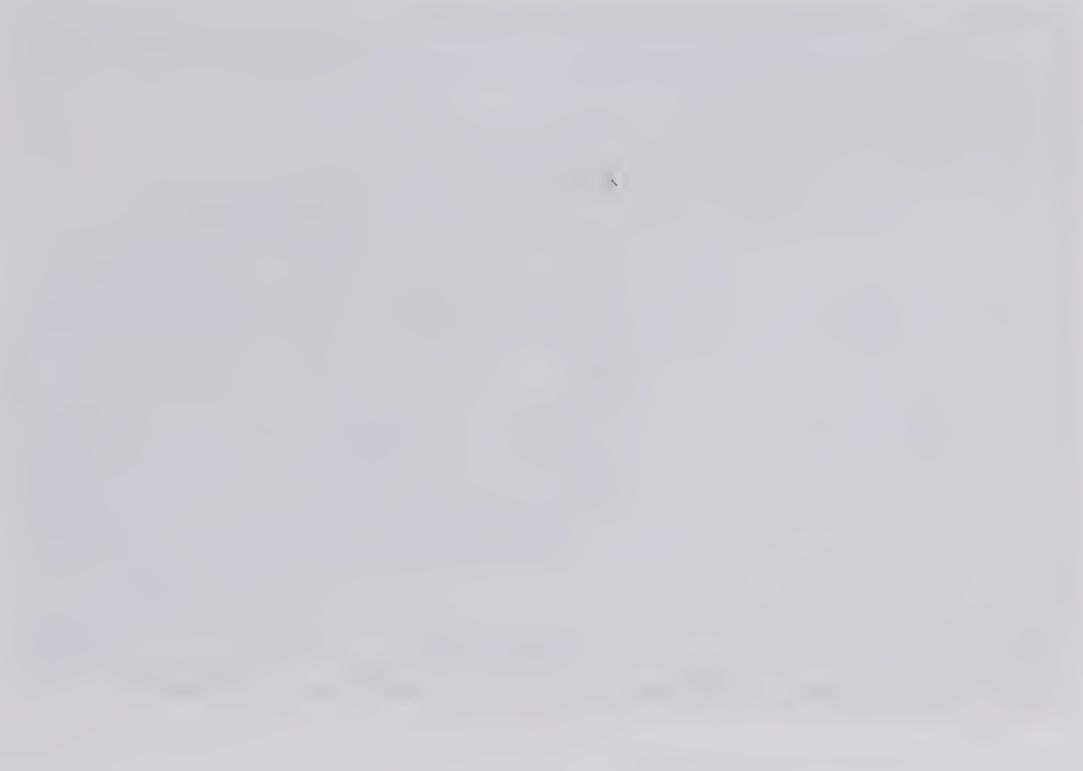
NESTING HABITAT DESCRIPTION

Characteristically, breeding sites selected by White Pelicans are islands; however, pelicans have been found nesting on mainland areas immediately adjacent to waterbodies. Observations (Houston 1962; Hosford 1965) suggest that a drop in water level after nesting had begun, resulted in the island being connected to the mainland. Security from mammalian predators has been cited as a benefit derived from the selection of island nesting sites by gregarious bird species (Crook 1965; Ward and Zahavi 1973).

All of the known nesting sites of White Pelicans in the Birch Mountain area are islands located in permanent waterbodies. At Birch Lake (Plate 1), where the pelicans nested in both years of this study, the rookery was located on a small clay, sand and scattered rock covered island. The island itself did not project more than 2 m above water level in either year and, in fact, was partly submerged by rising water levels in the mid-summer of 1976. Fluctuating water levels during July 1976 in the lake resulted from Beavers (Castor canadensis) creating impoundments on the outflow channel joining Birch Lake to Snipe Creek. Periodic removal of the Beaver dams in 1977 restored lower lake levels.

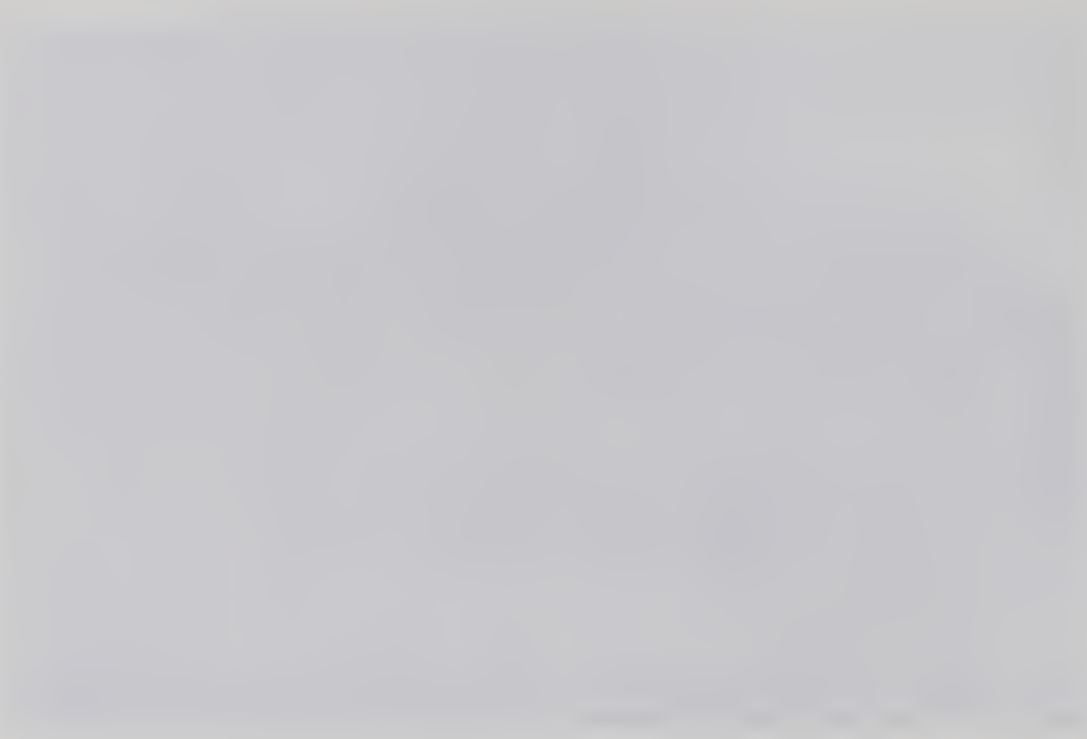
The exposed area of the island on 1 August 1976 measured approximately 30 m by 10 m, whereas on 19 August 1977, the island measured 90 m by 23 m. The island's highest point was located on the most westerly half and terrain sloped gradually in all directions to the water from that point.

Plate 1. Aerial photograph of Birch Lake, June 1977.



A portion of a courting flock at the rookery. A "courtship flight" involving a male (B) and female (A) is about to leave the island.


B



The island was practically devoid of vegetation although a fringing growth of Water Smartweed (Polygonum amphibium) was present in the offshore shallows. Several dead Willows (Salix spp.) on the western tip may have succumbed to fluctuating water levels in the past or they may have been trampled by the pelicans. Hardy invading plants such as Nettle (Urtica sp.), Mint (Mentha sp.), Lamb's Quarters (Chenopodium album), Celery-leaved Buttercup (Ranunculus scleratus), Dock (Rumex spp.), Cinquefoil (Potentilla sp.) and Sedges (Carex spp.) were found scattered on the periphery of nesting areas but were not common. The entire western and northern area of the lakeshore, used as both a loafing and foraging area, was a Sedge (Carex spp.) and Willow (Salix spp.) vegetated series of shallow channels and exposed mud bars.

White Pelicans frequently nest on depauperate landscapes throughout their breeding range and, to a certain extent, alter the degree and type of vegetation found there by their activities of trampling and guano deposition (Strait 1973; Trottier and Breneman 1976). Loose substrates on flat or gently sloping ground appear to be required for the construction of scrapes or nest mounds (Hall 1925; Behle 1935; Strait 1973; Knopf 1975a). Once established, a rookery site remains relatively free of ground cover if it is used every year. The Namur Lake site in the Birch Mountains has been invaded by woody perennial shrubs since its abandonment by the pelicans in 1975, a condition which may hinder subsequent recolonization there.

Open areas adjacent to the nesting areas appeared to be important to loafing pelicans not engaged in nesting duties or caring for young. Such areas provided space relatively free from harassment by nesting

pelicans and were used by arriving and departing flocks; hence, it is probable that islands which are completely and heavily vegetated are avoided by the birds. Presumably, as well, the open areas facilitate the mobile ground and aerial courtship displays of this species and enhance the high degree of visual and physical stimulation apparently required to stimulate breeding (Schaller 1964; Knopf 1975a).

The ability of White Pelicans to recolonize traditional breeding sites which have been rendered temporarily unsuitable or to establish new colonies on recently created islands (Bartholomew et al. 1953; Hosford 1965; Evans 1972; McCrow 1974) partially compensates for their vulnerability to fluctuating water levels and disturbance during the breeding season. Conditions of drought or flooding commonly affect many of the shallow prairie lakes they inhabit during the breeding season (Houston 1962).

The proximity of suitable foraging areas appears to be less a factor governing breeding site location than the inaccessibility of the islands which are selected (Vermeer 1970). The extensive flights to foraging areas up to 160 km distant from the rookery (Behle 1958) do not appear to be beyond the capabilitities of White Pelicans. Foraging areas identified in the Birch Mountains were located as far as 69 km from the rookery which was used in 1976 and 1977.

In Africa, breeding Pink-backed Pelicans and Great White Pelicans similarly flew great distances to forage (Brown and Urban 1969; Burke and Brown 1970). It is apparent that by using the technique of soaring, pelicans are able to cover such distances without difficulty even when fully fed and returning to the rookery to feed their young.

REPRODUCTIVE CHRONOLOGY AND PHENOLOGY

Spring Arrival and Distribution

A total of 33 White Pelicans was observed during the 26 April 1977 survey. Twenty-eight pelicans formed a low flying flock over the partially ice-free waters of the upper Ells River and five were in a small group in the only open water of the outflow channel at Birch Lake. Of the 48 lakes censused, only one was totally ice-free, 19 were partially ice-free and 28 were still frozen. Both the unnamed water-course flowing from Eaglenest Lake to the Gardiner Lakes and the Ells River flowing south from the Gardiner Lakes were partially ice-free.

The sighting of White Pelicans in the summer breeding territory before ice had melted in the majority of lakes was significant in that only two concentrations of birds were located: one at a known rookery site; the other near a known foraging area (Ealey 1979). Pelicans continued to use these areas throughout the spring and summer. In 1977, White Pelicans did not begin courtship at the Birch Lake rookery until ice had melted by 4 May, approximately one week after the distribution census was flown.

During the interval between arriving at the summer breeding grounds and initiating courtship, activities of the earliest arrivals were apparently restricted to open water areas. Certainly, the pelicans could only forage successfully in the open waters then available; however, by arriving early, they were able to initiate breeding immediately after ice-free waters ensured the security of the rookery site at

Birch Lake. Vermeer (1970) correlated the northern boundary of the breeding distribution for the White Pelican in Canada with the 0° C April isotherm, which suggested the importance of ice in effectively restricting the length of the reproductive season available to this species. I determined that in the Birch Mountains the normal ice-free period for lakes lasts from early May to early November, approximately 185 days. From the time the breeding birds begin courtship until all young mature sufficiently to begin migration, approximately 150 days must pass; thus, sufficient time is available for completion of the reproductive effort (Figure 2) given year to year variations in climate.

Daily and weekly counts of the number of adult birds present at the rookery throughout the entire breeding season in 1977 (Figures 3 and 4) indicated an early buildup of numbers of birds, presumably as newly arrived migrants joined the rookery. After nests had been established by early June (Figure 2), numbers of adults at the island began to decline as foraging occupied most of their time, particularly after young had hatched. Additionally, the departure of failed nesters from the rookery (see Schaller 1964) may have also contributed to the reduced numbers later in the year. Fall migration further reduced the number of adults at the rookery in September.

The weekly count from 19 to 25 July (Figure 4) was omitted due to the presence of large numbers of immature (as determined by plumage characteristics) White Pelicans visiting the island during that period. The origin of these birds could not be determined, but the sighting of one banded non-breeding bird and one banded breeding adult suggested

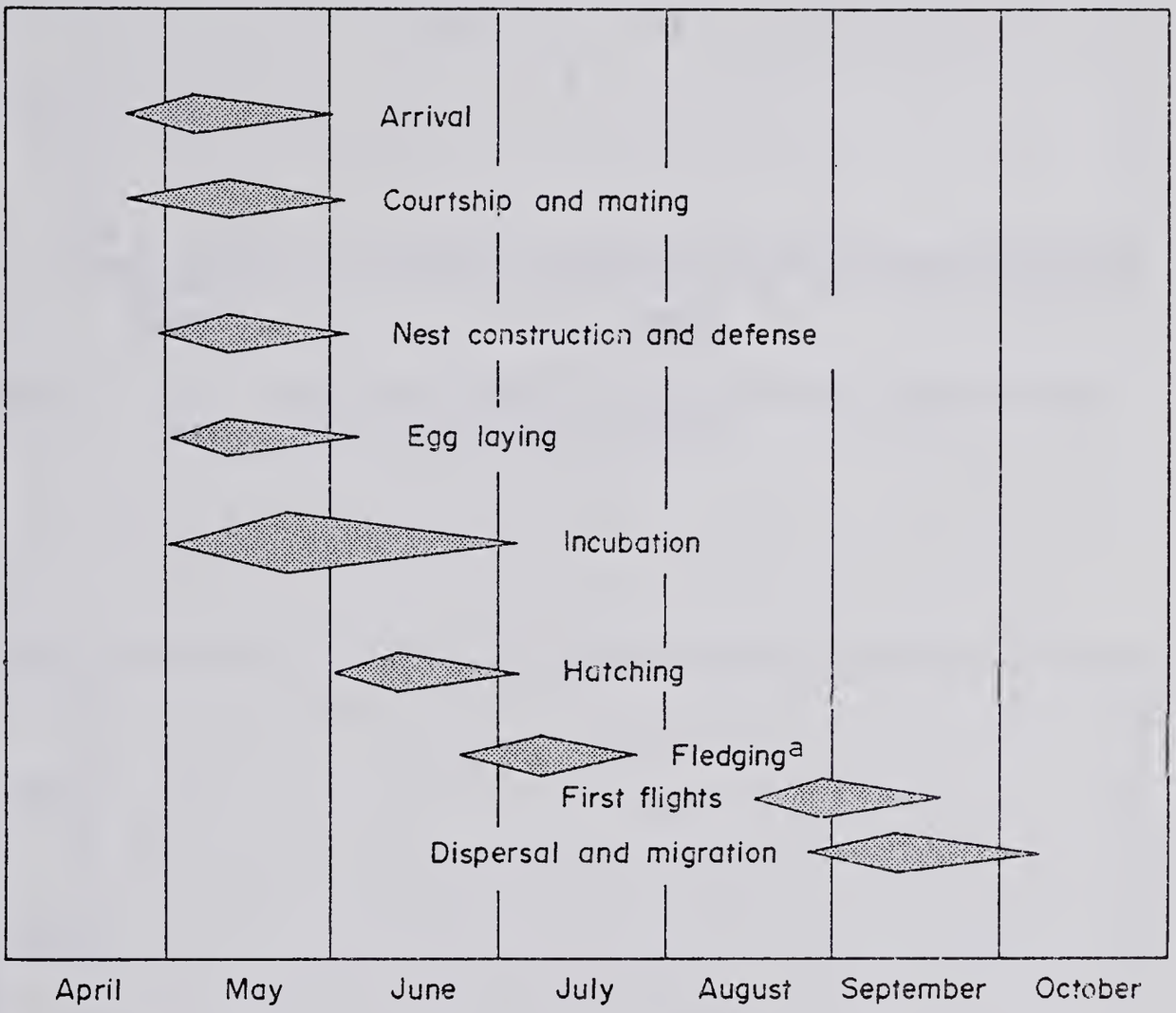


Figure 2. Chronology of reproductive events for White Pelicans at Birch Lake, northeastern Alberta.

[a] I considered fledging to mean the time when young left the nest.

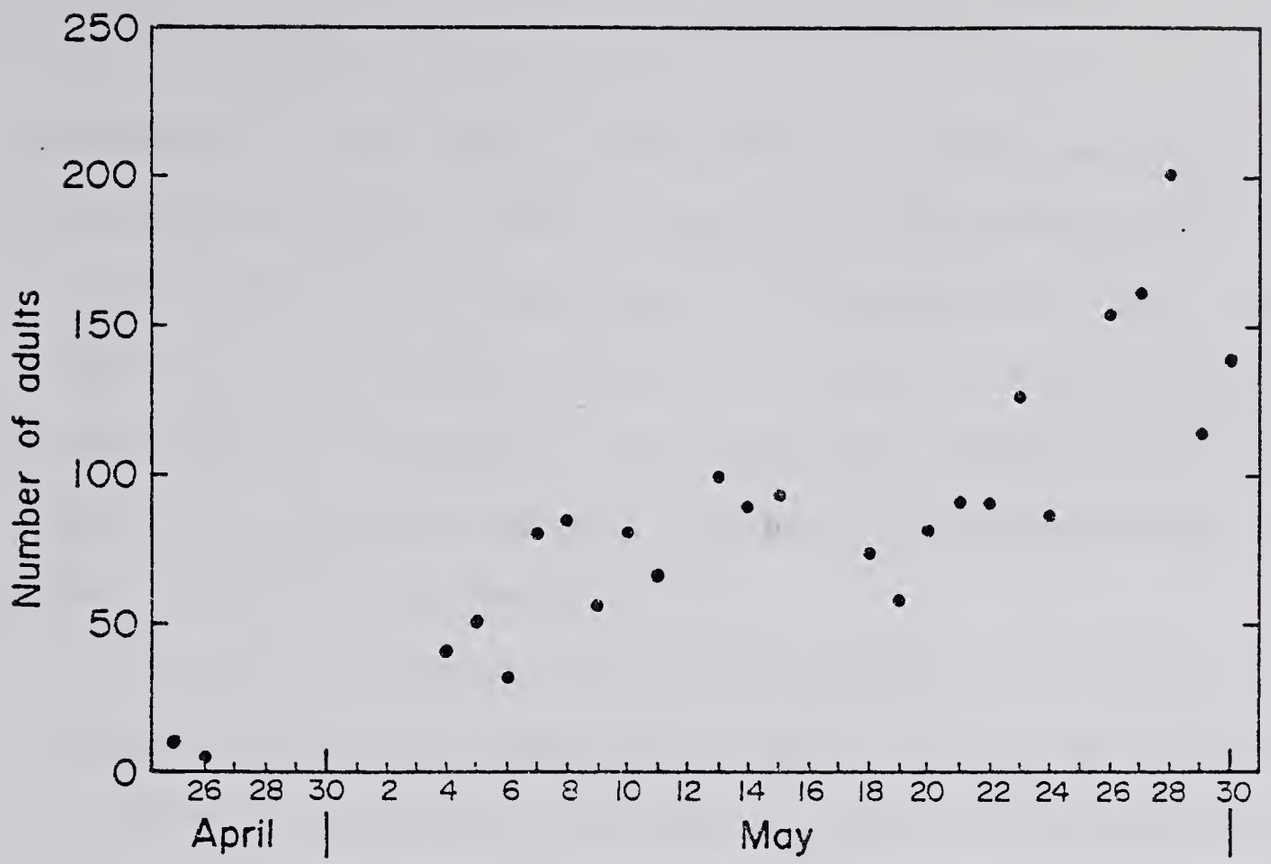


Figure 3. Daily maximum numbers of adults at the rookery from late April to late May in 1977.

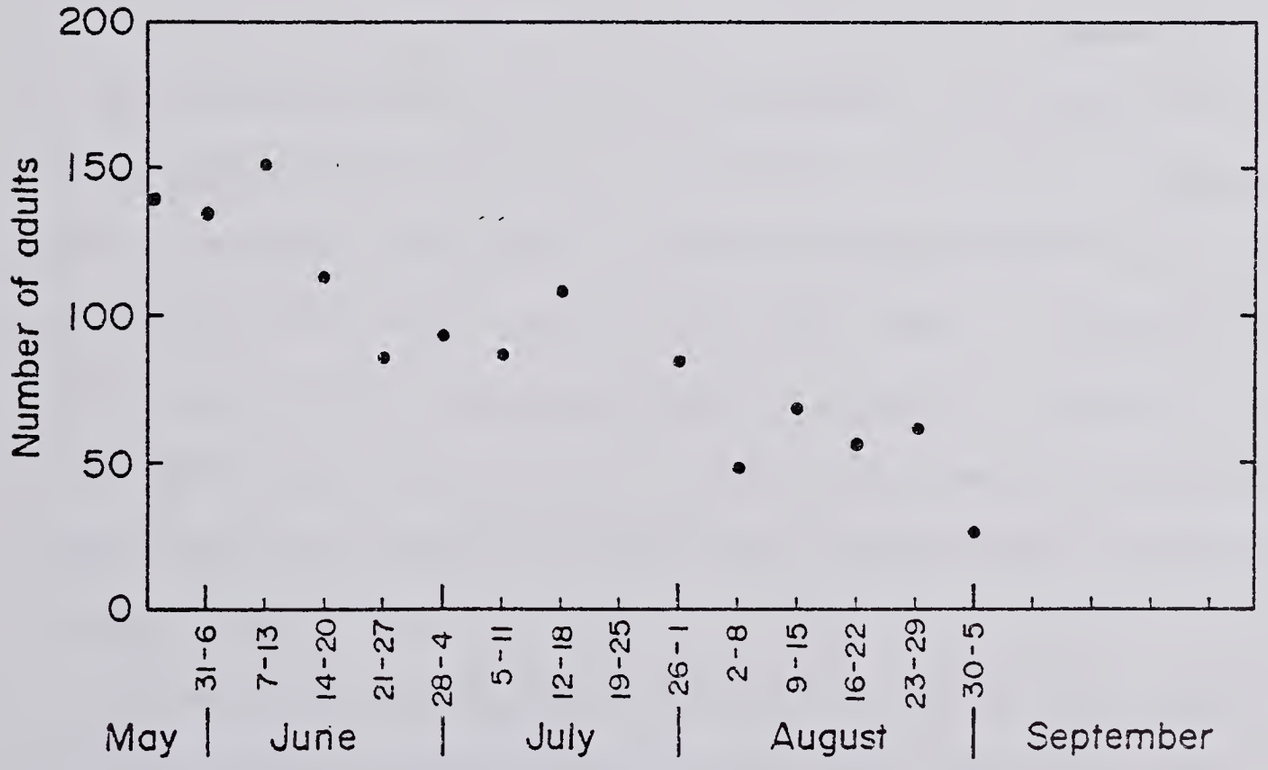


Figure 4. Weekly maximum numbers of adults at the rookery from late May to early September in 1977.

some movement in the summer by the birds as no banding has ever been carried out on the Birch Mountain population. The phenomenon was similar to a brief July influx of non-breeding adults observed in 1976. Strait (1973) determined that some juveniles from Chase Lake, South Dakota, did move northward into Canada in their wanderings, apparently lending support to a dispersal hypothesis explaining the presence of some non-breeding birds at Birch Lake.

The April 1977 aerial survey results suggested a possible first spring arrival in mid to late April in 1977. The last adults may have left during late September or early October when the last young would have been flying themselves. Observations in 1976 did not cover the spring phases of the reproductive cycle but by backdating from observed events (allowing 2 to 3 weeks for colony formation, 30 days for incubation (Bent 1922; Knopf 1975a) and estimating the age of hatched young), a first spring arrival date during the last week of April was suggested. In 1976, all adults and young had left by late September. The minor discrepancy between 1976 and 1977 departure dates perhaps reflected the degree of nesting asynchrony among colonies commonly observed for White Pelicans (Hall 1925; Behle 1935; Schaller 1964; Knopf 1975a). Development and growth rates of young may have also been variable for a number of reasons (food supply, temperature, etc.) which were not readily determinable. Year-to-year variations in ice conditions probably affect arrival and departure dates as well.

First spring arrival dates for White Pelicans at other rookery locations in North America are as follows: Great Salt Lake, Utah--15

March to 1 April (Knopf 1975a; Behle 1935); Lavallée Lake, Saskatchewan--26 April (Trottier and Breneman 1976); Yellowstone Lake, Wyoming--11 May (Schaller 1964). As previously discussed, ice cover may influence the timing of spring arrival for this species in temperate or boreal latitudes.

Nesting Synchrony

White Pelicans tend to nest in aggregations termed colonies which are spatially distinct from each other and which may be composed of birds at different phases of the reproductive cycle than birds in adjacent colonies (Marshall and Giles 1953; McCrow 1974; Knopf 1975a). At any rookery, colonies containing young may be found at the same time that other colonies are just beginning to incubate. Other researchers (Schaller 1964; Knopf 1975a) cited a lapse of only 2 to 11 days in both egg laying and hatching for most nests within a colony although this period could conceivably be longer in cases where later nests are appended to previously established colonies (Knopf 1975a). Knopf (1975a) also found that the degree of asynchrony among nests within a colony was independent of the number of nests within a colony. It appears that courtship, and events leading to egg laying, involve flocks of potential breeders (Plate 1) at relatively the same reproductive state. Knopf (1975a) noted an apparent direct relationship between the numbers of arriving migrants and the number of birds breeding the following week, a hypothesis also suggested by Ward (1924) and Behle (1958). Schaller (1964) and Knopf (1975a) suggested that if the birds arrived at

approximately the same time then mutual behavioural stimulation of birds in the same relative physiological breeding state could lead to the formation of distinct colonies. Their behavioural observations were comparable to the present study and suggest that both hypotheses have some validity.

Table 1 outlines the reproductive chronologies observed for colonies at Birch Lake in 1976 and 1977. The number of nests in each colony was determined from aerial photographs taken during the height of incubation in both years. The observations revealed that for seven individual colonies for which data were available, courtship and establishment of nests took from 7 to 14 days (mean = 9.3 days) but that periods of 12 and 29 days elapsed between the establishment of the first and last colonies in 1977 and 1976 respectively. Additionally, at least four nests in 1976 were appended to established colonies from 4 to 17 days after the last colony was established; in 1977, six nests were appended to colonies from 9 to 19 days after the last colony was established. These nests were not included in the determination of incubation and brooding periods for colonies (main periods) presented in Table 1. Although not all individual nests were observed for initial egg laying dates, the data suggested that the degree of asynchrony was greater within the larger (first formed) colonies, possibly due to the continual peripheral acquisition of nesters from nearby courting flocks. Knopf (1975a) noted that nests were only added to existing colonies when other courting flocks were present at the rookery. It is not known whether the incidences of later nesting which were observed in this study were

Table 1. Colony size and chronology of reproductive events for White Pelicans nesting at the Birch Lake rookery in 1976 and 1977.[a,c]

	Size		Event					
	Number of Nests		Courtship and Nest Defence		Main Incubation Period		Main Brood Period	
Colony[b]	1976	1977	1976	1977	1976	1977	1976	1977
A	70	28	April 27-May 4	May 11-24	May 4-June 3	May 22-June 21	June 4-June 25	June 22-June 13
B	53	10	N.D.	May 18-26	N.D.	May 26-June 25	N.D.	June 26-July 27
C	13	13	N.D.	May 25-June 4	N.D.	June 4-July 4	N.D.	July 5-26
D	4	11	May 25-June 1	May 26-June 1	June 4-July 4	June 1 - July 1	June 15-July 15	July 2-23
E	N.A.	8	N.A.	May 28-June 4	N.A.	June 4-July 4	N.A.	July 5-26

[a]Dates for events not actually observed in 1976 are based on estimates derived from backdating.

[b]Colony designations were assigned to identify spatially and/or temporally separated groups of breeding birds and do not necessarily imply the integrity of colony units from one year to the next.

[c]Symbols: N.D. = No data; N.A. = Not applicable.

renesting attempts of previously failed nesters, the result of observed sporadic late courtship at the rookery or a combination of these two factors.

Knopf (1975a) hypothesized that the mechanisms limiting colony size were the number of females breeding and the number of flocks courting simultaneously on the rookery prior to colony formation. He observed competition for females among the more numerous males in courting flocks. As this situation was also observed at Birch Lake in 1977, the mechanisms he proposed are probably operative in determining colony size. Similar mechanisms also seem to apply to Great White Pelican colonies forming at rookeries in Africa, as described by Feely (1962), Brown and Urban (1969) and Brown et al. (1973), where males also appear to compete for mates in courting flocks on the ground and in the water. At Birch Lake, physical antagonism by nesters toward pairs attempting to nest on the peripheries of colonies in the advanced stages of incubation operated to cause abandonment of the nesting attempt by some annexing pairs. Beyond what Knopf (1975a) suggested, courting flocks may not only have lost their attractiveness to new pairs from 5 to 7 days after they began to form colonies, but physically may have prevented successful annexation of many new nests during incubation.

Nuptial Plumages and the Presupplemental Moult

Observations at Birch Lake substantiated Palmer's (1962) assertion that breeding birds arrived in spring in the alternate (nuptial) plumage. No evidence was found to substantiate indications (Palmer 1962) that

(juvenile) birds bred before this plumage was attained. The nuptial plumage is characterized by the presence of pale yellow or white crest plumes, pale yellow upper breast feathers, bright orange feet, bill and pouch and a fibrous horn(s) on the distal third of the upper maxilla. The bare skin around the eyes is bright yellowish orange. It appeared that the behaviours exhibited during courtship and pairing emphasized these features. Males are generally larger than females but both sexes are otherwise superficially similar in this plumage phase.

The nuptial plumage is apparently retained until the commencement of egg laying and incubation and thereafter a presupplemental moult (Palmer 1962) of the head region gradually alters the appearance of the breeding birds until the supplemental plumage is acquired. The supplemental plumage is accompanied by paler colouration of the pouch, bill and skin around the eyes and feet. The horn is shed contemporaneously with the loss of the crest plumes (Palmer 1962; Knopf 1975b) and the head and neck regions become feathered in shorter gray or black feathers of varying patterns and extent. Counts of numbers of individuals possessing horns and crest plumes at successive stages of the reproductive cycle at Birch Lake documented the onset of the presupplemental moult and the attainment of the supplemental plumage by mid-summer (Figure 5). The figure included the partial late season counts of these features in 1976. The data demonstrates the generally changed appearance of the parent birds once young had left the nest, lending credence to Knopf's (1975b) suggestions that chicks may have been partly assisted in the recognition of their own parents at feeding time using the colour patterning of the head region as cues (Schaller 1964; Knopf 1975b).

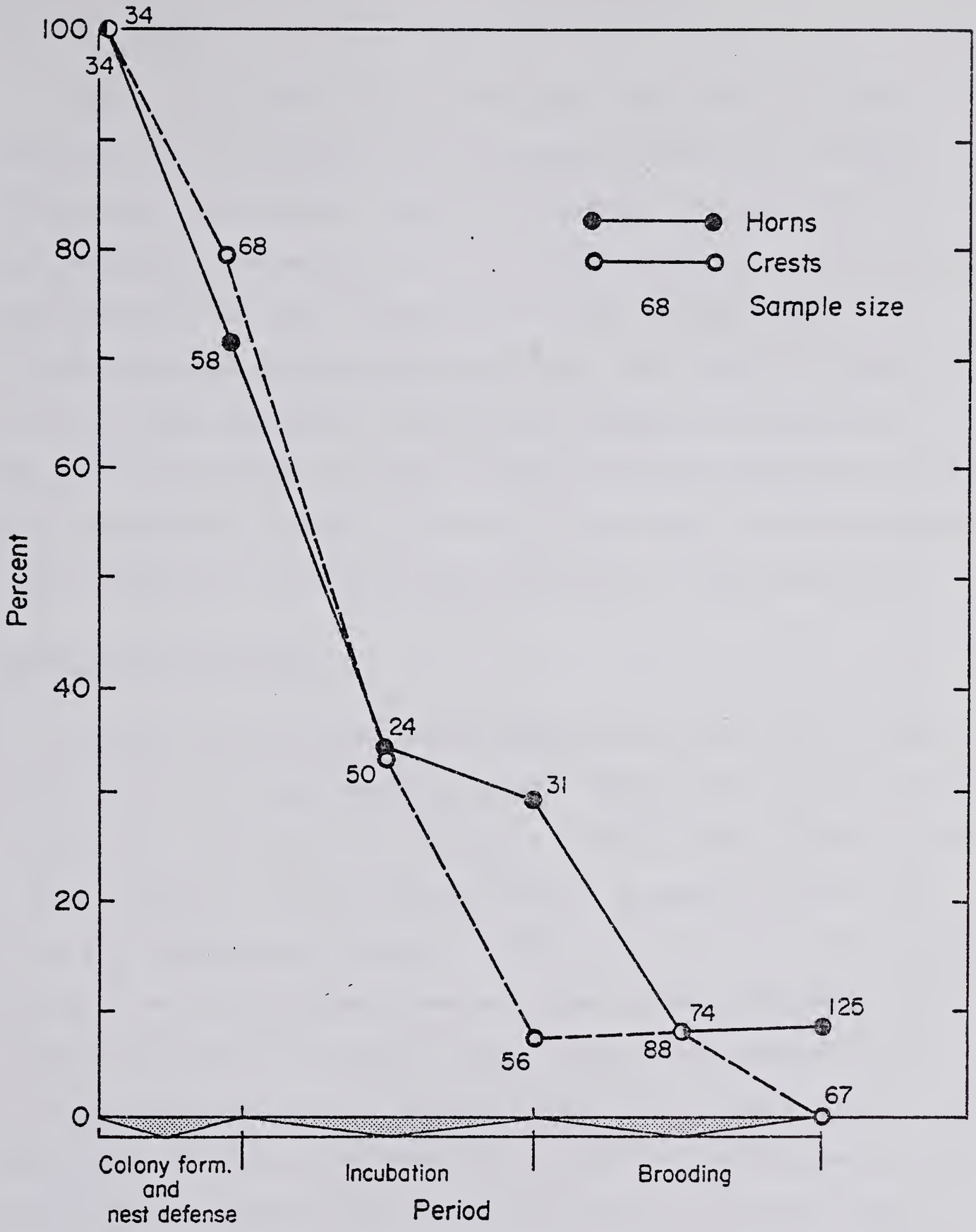


Figure 5. Percentages of adult White Pelicans possessing a horn or nuptial crest plumes (white or pale yellow) relative to reproductive events at the rookery.

The behaviour observations at Birch Lake demonstrated that when young had left the nest and formed aggregations termed pods (Schaller 1964), parents returning to feed them frequently travelled from pod to pod waiting for approaches by their own begging young. Parents, however, fed only their own young. Both Schaller (1964) and Hall (1925) also stated that adults feed only their own young. The function of other cues in parent-young recognition remain to be thoroughly investigated for White Pelicans although it seems reasonable to assume that auditory cues by grunting adults (Schaller 1964) and wailing young at feeding time may also assist mutual recognition during the period of young dependence.

Description of Colonies

At Birch Lake, colonies formed around a nucleus of first initiated nesting pairs and spread from that point. Colonies were not always formed sequentially; two or more colonies could be formed simultaneously at the rookery (Table 1). Colony formation was not observed in 1976 due to a late field season start; however, the observations of four distinct nesting groups in aerial photographs taken on 27 May 1976 and subsequently three distinct age groups of fledgling young, supported the hypothesis that colonies formed over a period of approximately 3 to 4 weeks during May (Table 1). The projection of the colour slides obtained during the census flights revealed four established colonies in 1976 and five in 1977 during the height of the nesting season from late May to early June. Not all the available space at the rookery was used in either year although the higher areas were colonized first by the largest colony. Figure 6

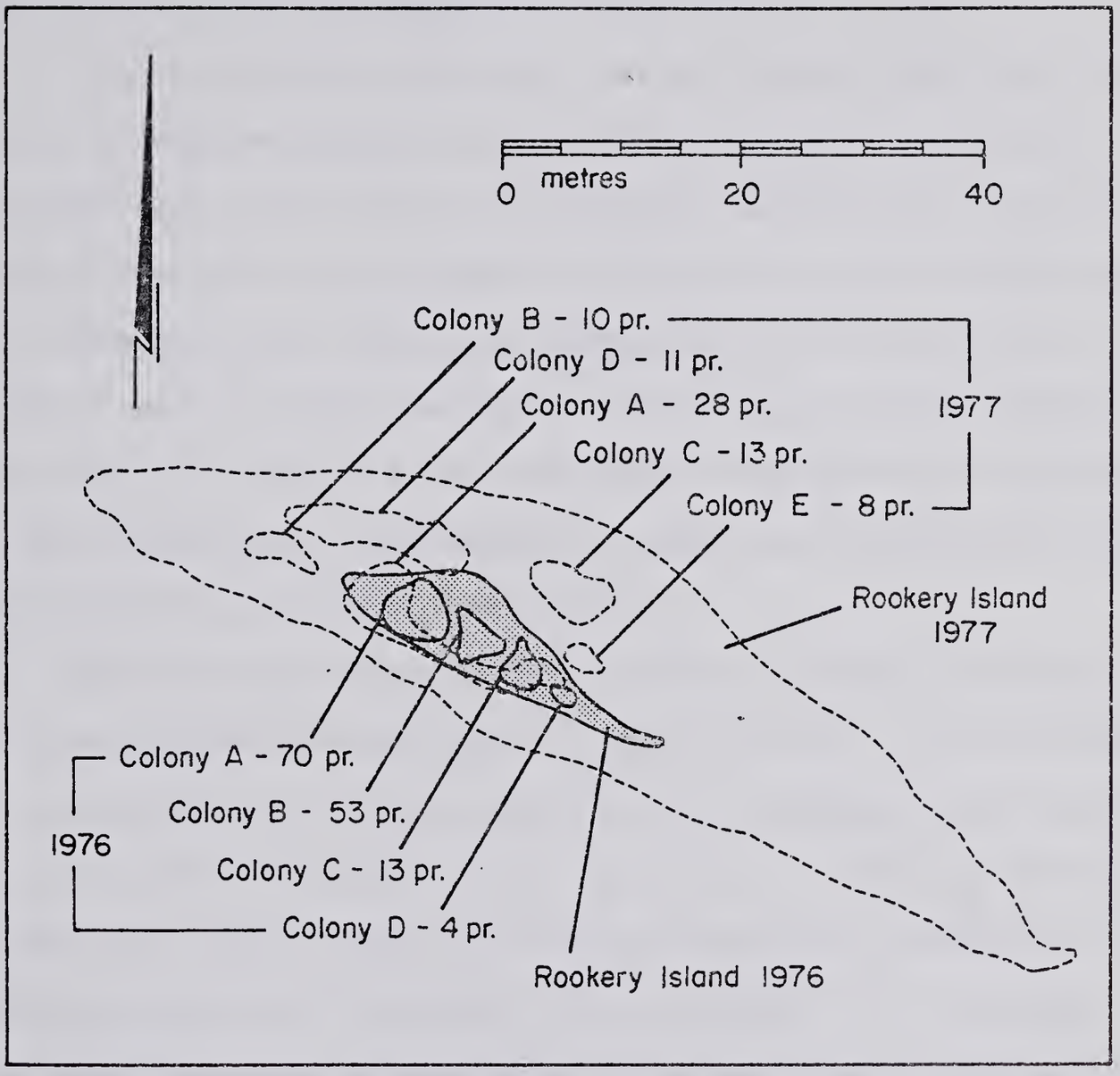


Figure 6. Location and size of nesting colonies of White Pelicans at the rookery in 1976 and 1977.

shows the estimated number of nests in each colony location for 1976 and 1977. The apparent density of nests was greater in 1976 than in 1977, reflecting the larger number of pairs breeding on a smaller area in 1976. It appeared that birds avoided nesting in areas closer to the water, possibly diminishing the amount of flooding of their nests.

In 1977, during the time of most active courting, 202 birds in the nuptial plumage were observed on the island; however, only 76 pairs initiated nests. The factors underlying the failure of the remaining 50 birds to nest may involve unequal sex ratios in the breeding population, i.e., more males than females, as suggested by counts of the sexes of birds in courting flocks observed in this study and by Knopf (1975a) or the presence of immature birds in the nuptial plumage which did not pair or nest successfully. More research is required to determine the plumages associated with the year of first breeding.

The areas where colonies formed in 1977 overlapped, but were not superimposed upon the areas chosen in 1976 (Figure 6). Colonies formed in close proximity to existing colonies but, in 1977, were not nearest the most recently established colony as was true in 1976. At Gunnison Island, Utah, Knopf (1975a) noted the partitioning and orientation of colonies along natural formations such as driftwood lines and rocks. This partitioning was not observed at Birch Lake, however, due to the paucity of such features on the island. The only apparent basis for the observed organization of colony orientation was a temporal one, in that the first formed (largest) colonies were on the higher elevations with subsequently formed colonies, of necessity, restricted to lower elevations surrounding the island's crown.

BEHAVIOUR

Description and Chronology of Behaviours

The following is a documentation of the behaviours exhibited by breeding birds observed at Birch Lake throughout the reproductive season. Although the same names have been assigned to similar behaviours described for other pelican species as outlined in the Introduction section, no homologies should be implied until further work is completed on the functional aspects of posturings as determined by their patterning through the entire year for all pelican species.

Temporal patterns for some behaviours of adult White Pelicans over the 1977 season were determined by either their occurrence or lack thereof during successive weekly time periods (Figure 7). The relative importance of the numbers of birds present on the rate of occurrence of several specific behaviours, namely, "courtship flights," "aggressive lunging" and "copulatory mounting," which appeared to characterize interactions among the birds at different times during the reproductive season, was assessed.

For the purpose of this discussion, the 1977 reproductive events associated with colonies and, to a lesser extent, the more infrequent earlier or later expressions of reproductive behaviour by some birds will be considered. Specifically, the time periods associated with the following reproductive events in all colonies (Table 1, Figure 7) will serve as reference points for this discussion:

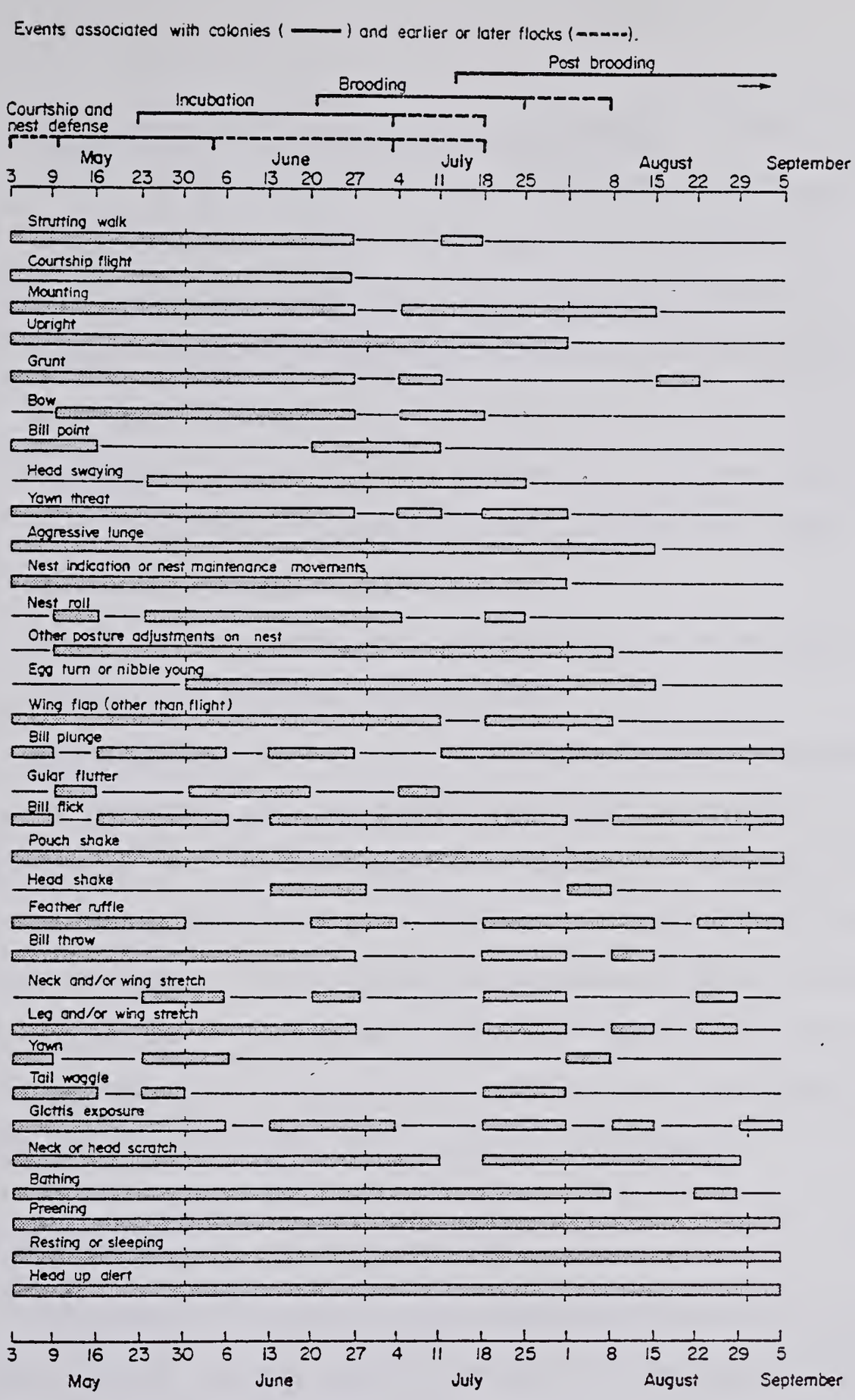


Figure 7. Occurrence (shaded bars) of behaviours demonstrated by adult White Pelicans at the rookery throughout the reproductive season in 1977. All behaviours involve adults only, except "mounting", which includes demonstrations of this behaviour by adults toward young of the year.

colony formation (courtship and nest defense): 11 May - 4 June. Earlier courtship before the actual start of colony formation was noted during the week from 3 to 9 May. Periodically, after approximately 90% of all nests had been established in colonies, small courting flocks were observed at the rookery as late as mid-July.

incubation: 22 May - 4 July. Additionally, six nests appended to colonies that were already formed, extended the incubation period approximately 2 weeks.

brooding: 22 June - 26 July. Later nesting birds extended the brooding period approximately 2 weeks.

post-brooding: 13 July - end of study period (early September).

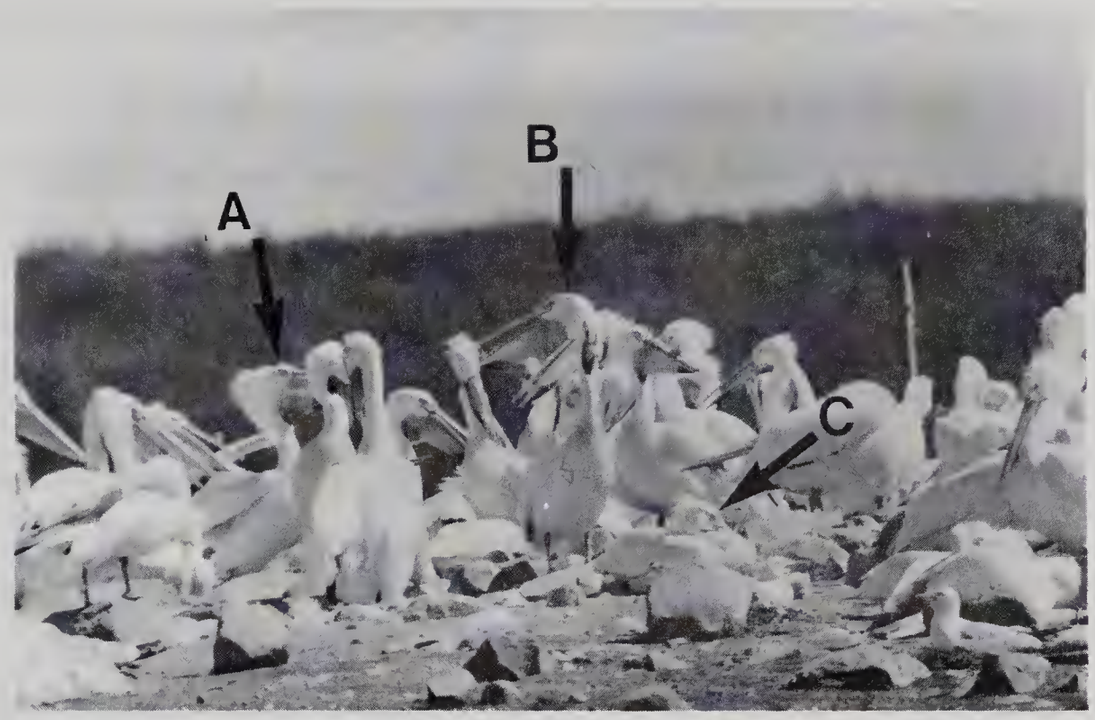
Few behaviours were restricted to one particular phase of the reproduction cycle but were observed throughout the study period. Many behaviours associated with courtship were also observed during nest relief ceremonies. Several behaviours associated with maintenance of the body surface or comfort were infrequently observed and their lower rate of occurrence would account for their absence from several of the intensive 10-minute observation periods of individuals.

"Strutting Walk"

This behaviour (Plate 2), first described for White Pelicans by Schaller (1964) was displayed by both sexes only during courtship. The pairing process began with the aggregation of birds in the courting flocks which eventually resulted in the formation of discrete colony units.

Plate 2. Other behaviours during courtship: "upright" (A and B). Bird (C) rests.

A late courting pair. The male at left which has lost his horn and crest plumes "struts" behind the female at right.


A
B
C

Usually, the larger males followed the females in an exaggerated stepping fashion which appeared to emphasize the nuptial crest plumes, the brightly coloured bill, pouch and feet and bill horn. The wings were held slightly apart from the body with the neck erect and bill pointed down against the neck and breast toward the feet so that the occipital crest plumes were prominently displayed. "Strutting" pairs frequently broke away from the courting flocks on the island and rejoined the flocks after "courtship flights." Between episodes of "strutting," other displays and maintenance behaviours were interspersed. The behaviour ceased with the establishment of nests by pairs within the forming colony.

"Courtship Flights"

"Courtship flights" (Schaller 1964) were similarly observed only during the pairing process and in association with courting flocks (Plate 1). A typical flight involved the aerial pursuit of one or more females by one to several males in a circuit of the rookery or surrounding lake. Females initiated the flights in 20 of 22 instances where the sex of the leading bird was determined by size; larger males led in only two instances. In 54 airborne flocks where size differences were determined for the component individuals, at least one smaller (female) bird occurred in 52 instances, two females in 11 instances and three females in two instances. Single males occurred in 52 of these flocks, two males in 20 of them and three or more males in 11 flocks. Flock sizes varied from two to twenty birds.

"Courtship flights" were most pronounced during the period from 1000 to 1600 when 169 of the total 216 flights were observed (the observation time alloted for this daily period from early May to early July when courtship flights were occurring was 96.6 hours compared with 109.8 hours devoted to other periods of the day). Figure 8 presents the frequency of occurrence of "courtship flights" in the period from early May to early July in 1977 and reveals the peak in occurrence of this activity during the week of 24 to 30 May when the courting flocks which subsequently formed all colonies were active.

That the higher rates of occurrence of "courtship flights" observed were not entirely attributable to the number of birds present on the rookery, was demonstrated by the following analysis. The mean number of birds present at the beginning of observations from 3 to 9 May was 30.7 (standard deviation = 20.3) based on 27 hourly counts. During the week of peak rate of "courtship flight" occurrence from 24 to 30 May, a mean of 119.9 (standard deviation = 30.6) birds was present based on 36 hourly counts. Similarly, in the week from 7 to 13 June when the rates had decreased dramatically, a mean of 74.2 (standard deviation = 11.8) birds was present at the island based on 26 counts (Figure 8). It appeared that "courtship flights" involved birds that were pairing and that when maximum numbers of birds were pairing, rates of this behaviour were highest. However, although numbers of birds at the rookery were still relatively high once nests had been established and pair bonds formed, the rates were much lower. A resurgence of higher rates occurred with the activity of later courtship flocks which subsequently formed colonies

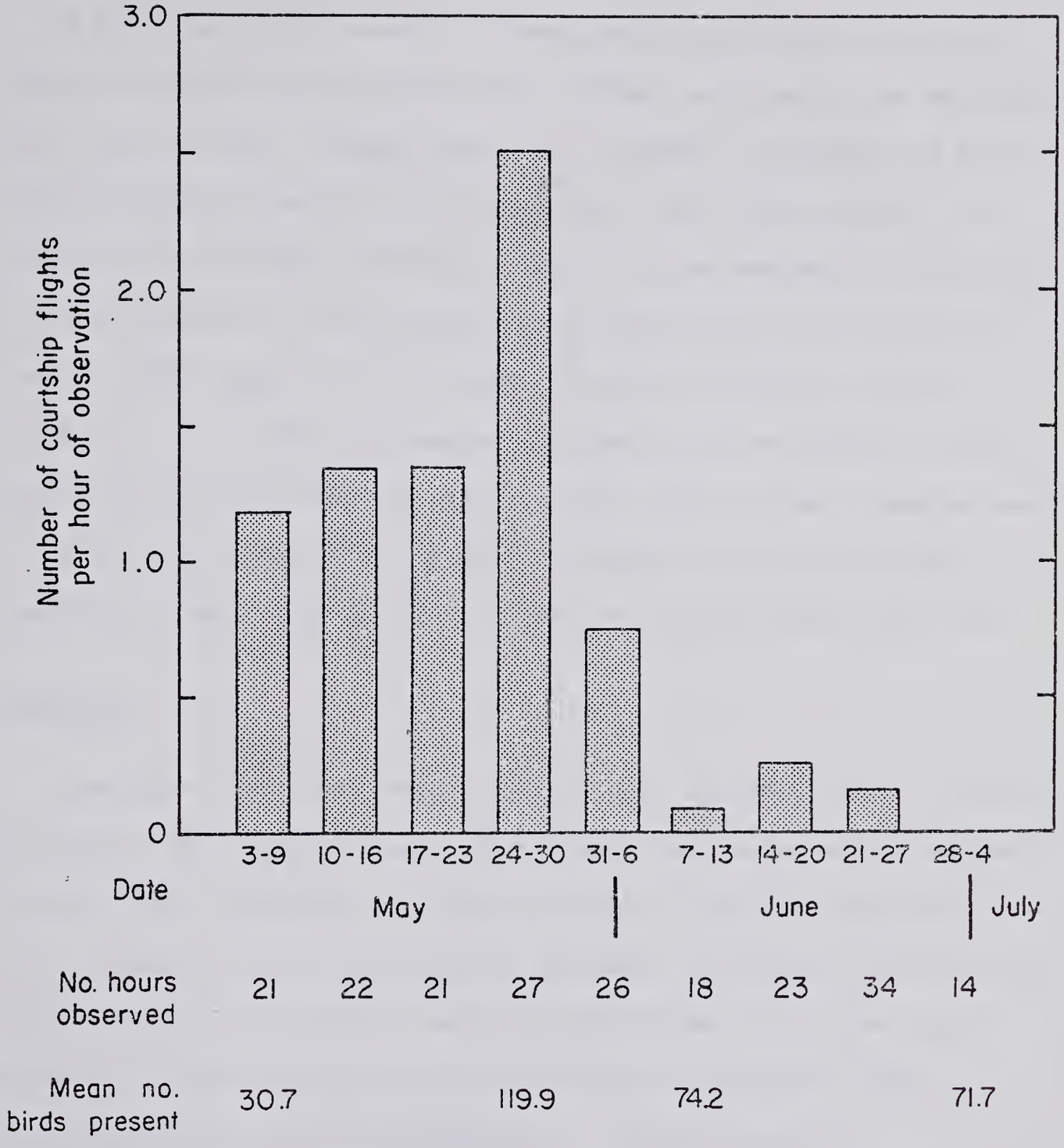


Figure 8. Rate of occurrence of "courtship flights" by White Pelicans from May to early July in 1977.

B, C, D and E although birds on nests in colony A were quiescent in this respect.

A brief spate of "courtship flight" activity was observed in mid-June which could have involved birds previously unsuccessful at obtaining mates, late arrivals, inexperienced first breeders, or members of pairs that had failed in earlier nesting attempts. The exact nature of this demonstration of later courtship by White Pelicans has not be documented in the literature but Nice and others (in Knopf 1975a) have determined that for other migratory bird species the older individuals tend to arrive in spring before the younger. Perhaps, at Birch Lake, the later courtship reflected later arrivals of young birds, but more research would be required to ascertain this pattern for White Pelicans. The last "courtship flight" observed at Birch Lake in 1977 occurred on 26 June.

"Mounting"

Copulatory "mounting" among breeding birds involved the male grasping the neck of the crouched females in his mandibles then stepping onto her back with "wing flapping" to maintain balance (Plate 3). The female, while crouched and before mounting by the male, infrequently vibrated her slightly open wings while her neck was outstretched low to the ground anteriorly. After dismounting, both birds were observed to engage in various activities which are described in following sections.

"Mounting" among adults was usually confined to later phases of courtship between pairs, although a few instances of indiscriminate "mountings" of incubating females by males were noted on colony

Plate 3. Male (A) copulates with mate at defended nest site. Birds (B) sleep as well, even though surrounded by courtship activity.

A mated pair "lunge" aggressively at a neighbouring nester. Such scenes are common during colony establishment and incubation.


A
B

peripheries. Without exception these later copulation attempts were unsuccessful, and were resisted by the aggressive females, suggesting that the receptivity of the females had altered after courtship and selection of a nest site. Males, in these instances, apparently initiated the copulation attempt in the absence of few behavioural cues other than the crouched posture of the females on nests.

Adults (presumably males)also attempted copulations with young which had just recently left their nests in July and August in both 1976 and 1977. Of a total of 219 such attempts observed, the estimated ages of 79.2 percent of the 48 young involved were between the ages of 2 and 3 weeks. No copulation attempts on young less than 1 week or older than 5 weeks of age were observed and these copulation attempts, as for those on incubating females, appeared to be stimulated by the crouched posture of the young which were barely able to stand upright. Schaller (1964) also hypothesized that copulation attempts were stimulated by the resemblance of crouched young to soliciting females, particularly when the young flicked their wings when begging for food. Van Tets (1965) observed the behaviour's similarity to "uncoordinated forms of courtship" away from the rookery in other Pelicaniform species. Adults of other pelican species observed to attempt copulation with young are the Great White Pelican (Brown and Urban 1969) and the Pink-backed Pelican (Din and Eltringham 1974). Intruding males were implicated in both of the latter citations although no indications of the reproductive status of the males were given.

From 10 May to 20 June in 1977, a total of 121 copulations or attempted copulations among adults was witnessed. Copulatory "mounting" among adults reached peak rates of occurrence during the weeks from 10 to 16 May and 24 to 30 May (Figure 9) when most pairs were establishing and defending nest sites within the forming colonies. From 10 to 16 May a mean of 52.9 (standard deviation = 28.6) birds was present at the rookery, based on 42 hourly counts, whereas from 24 to 30 May, a mean of 119 (standard deviation = 30.6) birds was present, based on 42 hourly counts. The rate of activity was apparently not exclusively related to the number of birds present but also to the number still actively pairing and seeking potential nest sites (colony A had been established by 24 May) in courting flocks.

Courting flock locations were ephemeral during May. Although at least 10 females had selected nest sites and were actively defending them with their mates, shifts in the location of the courting flock apparently resulted in their abandonment of that effort and relocation nearer the courting flocks during the period from 13 to 30 May. Mutual stimulation of the birds through courtship behaviour and social interaction was apparently intense before nest site tenacity occurred; these stimulations, predominant in flock situations, preceded copulation, nest construction and egg laying and doubtlessly enhanced the degree of synchrony of reproduction within a colony as suggested by Knopf (1975a).

The following behaviours observed during courtship were not restricted to that phase of the reproductive cycle but persisted for varying periods of time thereafter through the incubation, brooding and

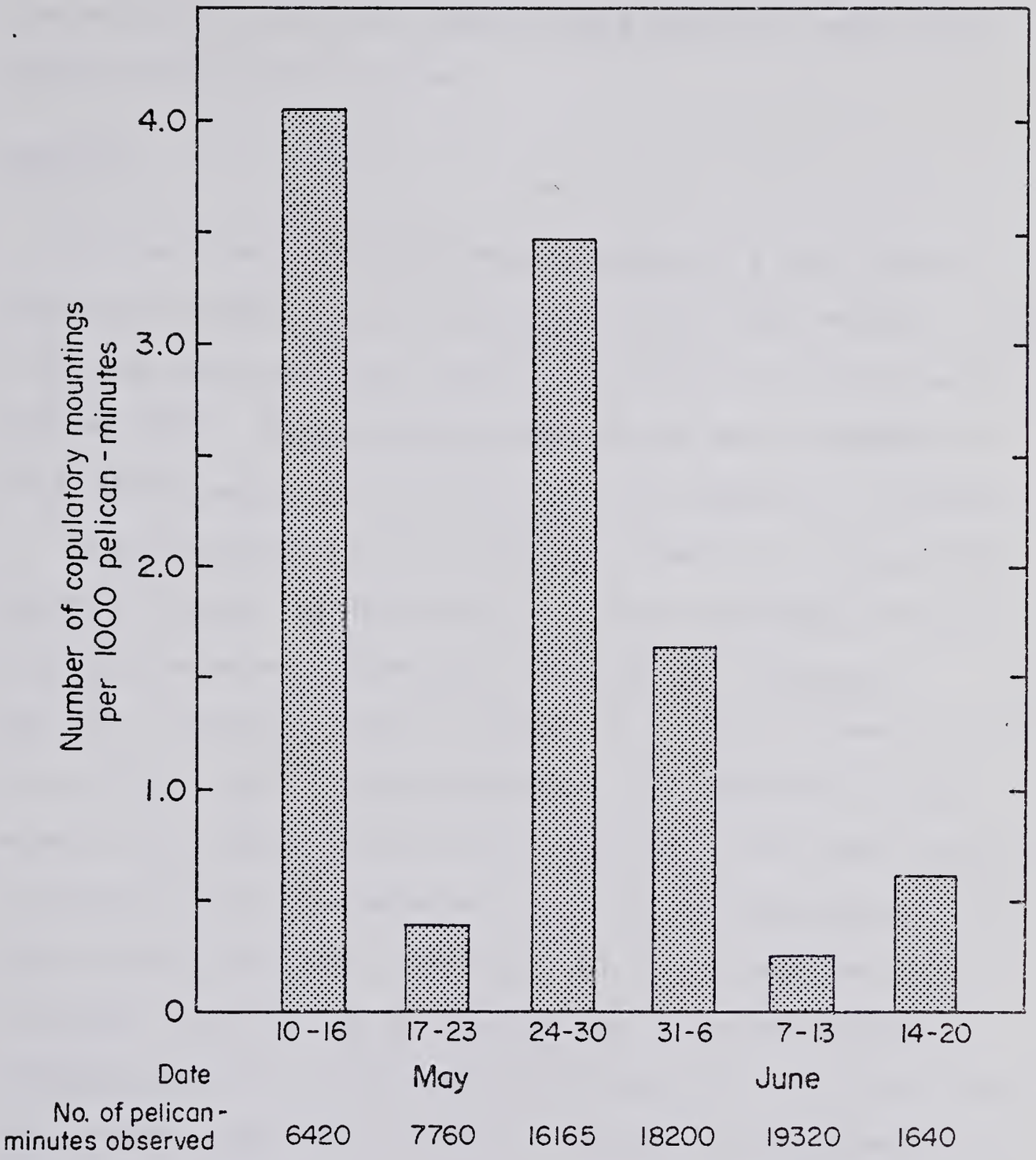


Figure 9. Rate of occurrence of copulatory "mountings" among adult White Pelicans in 1977.

post-brooding stages. It appeared that, in addition to facilitating the pairing process, these behaviours served to maintain the pair bond or involved social interactions among pelicans generally, regardless of whether they were paired or not.

"Upright"

This term was derived from the description of a very similar behaviour in Brown Pelicans offered by Schreiber (1977) and may in fact be the same behaviour termed "head up" for White Pelicans observed by Schaller (1964). The term "pouch expansion" by van Tets (1965) and Knopf (1975a) appears to be a description of a component of "upright."

Both sexes performed this behaviour, frequently in groups during courtship (Plate 2) but also during nest relief ceremonies and before and after copulation. It was also associated with "grunting," particularly during courtship in response to movement of other courting birds milling around. Males were observed to demonstrate a similar behaviour as an aerial display prior to landing on the rookery after a "courtship flight." The behaviour involved stretching the pouch by a slight bowing of the lower rami while the bill was raised above the horizontal. "Upright" was not observed once adults had detached themselves from the nest after young had fledged (Figure 7) and formed pods, and thus appeared to function in recognition between potential mates and pair members. The similar behaviour described as "head up" by Schaller (1964) was thought to be a greeting and this appears to have been the case at Birch Lake where "upright" was observed between pair

members. Group "upright" displays during courtship, frequently coupled with "grunting," appeared to reflect a more general awareness of the activities of pelicans by each other at that time. Perhaps the posture was a mild threat as described for the pouch expansion by van Tets (1965). The aerial expression of this behaviour did not, however, appear to bear any resemblance to the food begging behaviour of chicks to which van Tets (1965) attributed its derivation. Schaller (1964) also observed aerial "head ups," supporting the view that "head up" and "upright" are equivalent.

"Grunting"

Vocalizations are frequently associated with the courtship displays of other pelican species for which information has been reported, with the possible exception of the Pink-backed Pelican (Burke and Brown 1970). At Birch Lake, only two distinct types of "grunting" were discernible, each performed by both sexes although males appeared to be more vocal. The first type involved the utterance of a series of hoarse grunts associated with the "upright" during group display. The second, a softer moaning sound, was heard during the nest relief ceremony only. A third type, described by Schaller (1964) and apparently given by adults feeding very small young was not heard; perhaps due to the general vociferousness of the older young present when foraging flocks returned to feed young. "Grunting" was heard only twice when a pelican was flying; the significance, if any, of these utterances was not clear.

"Grunting" emanated frequently from the rookery during the courtship phase, often in the absence of any visible display. "Grunting" was heard

late at night when most pelicans had settled down for the evening and characterized other social interactions such as "aggressive lunging." The behaviour therefore appeared to be a mild threat as well as a component of recognition perhaps depending on the acoustic qualities of the utterance. Brown and Urban (1969) indicated that different vocalizations appeared to typify recognition and aggression as well as feeding of young for Great White Pelicans in Ethiopia. Vestjens (1977) was also able to discern various vocalizations in context with the behaviours of the Australian Pelican.

"Bowing"

"Bowing involved the arching of the neck with the tip of the bill pointed at the ground beneath the breast and feet and also a perceptible expansion of the pouch as in "upright." Both sexes "bowed" and performed "uprights" before and after copulation. "Bowing" was also observed during nest reliefs by pairs and with individuals receiving jabs from nearby pelicans during courtship and nest site selection. The behaviour was not observed after 19 July in 1977 (Figure 7) after which most adults were brooding young and nest relief ceremonies appeared to be less ritualized.

"Bowing" thus appeared to function as a recognition or appeasement display and as a preliminary and post-copulatory behaviour. Variations of "bowing" behaviour have been recorded for all other pelican species for which observations have been reported (van Tets 1965; Brown and Urban 1969; Burke and Brown 1970; Schreiber 1977; Vestjens 1977) and appear to occur in similar contexts during courtship, nest relief and as

responses to threats or physical aggression, particularly during courtship.

"Bill Pointing"

Both sexes performed "bill pointing," which was little more than a further upward extension of "upright" previously described. During the posture, pair members often rotated the head from side to side. As the behaviour was performed by pair members only during courtship and nest relief (Plate 4), it was often associated with both "head swaying" and "bowing." "Bill pointing" functioned as an apparent recognition or greeting display exclusively, and ceased in July (Figure 7) as nest relief ceremonies diminished in intensity. This greeting was not observed after mid-July when adults seldom associated with each other at the nest.

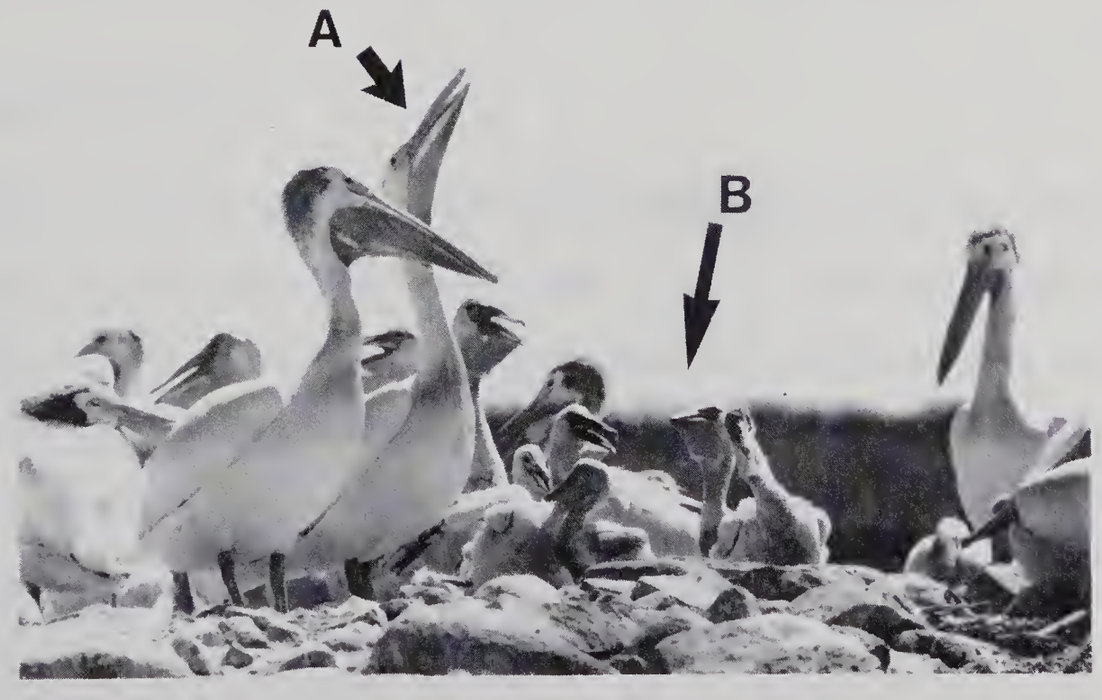
"Head Swaying"

The mechanics of similarly named behaviours in the Brown and Australian Pelicans have been described by Schreiber (1977) and Vestjens (1977) respectively. "Head swaying," as described by Schaller (1964) for White Pelicans, is probably the same behaviour that was observed at Birch Lake. The performance of this behaviour involved a slow twisting of the head through a horizontal figure-eight motion in front of the body with the bill slightly agape and the pouch slightly inflated as during "bow."

"Head swaying" was performed by both sexes only during the latter phases of courtship and in the nest relief ceremonies, serving as a

Plate 4. Bird (arrow) "indicates" nest with bill while birds in immediate background and left foreground preen.

During a brooding relief ceremony an adult (A) performs a "bill pointing" display beside mate. Their young are beginning to associate with other young in aggregations called pods (B).


A
B

recognition and greeting display. As with the "bill pointing" display, "head swaying" ceased in July (Figure 7) as pair members associated less at the nest.

"Yawn Threat"

This behaviour was interpreted to be an expression of aggression as it was frequently performed during physical conflict situations among birds in a group. The mechanics of "yawn threatening" involved the pointing of the bill toward another bird (conspecific or otherwise) then opening the bill while spreading the lower rami apart to create an expanse of taut pouch skin facing the object of the threat.

"Yawn threats" were given in defense of nests during their establishment and during incubation and brooding. Threats were also observed among loafing birds, apparently to discourage encroachments by other pelicans upon loafing space. The cessation of this behaviour after early August was interpreted as an indication of lessening of aggressive tensions among the birds as their nesting territories were vacated.

"Aggressive Lunge"

This activity was frequently observed during situations where several birds were interacting when males were courting females, during nest site defense by both sexes (Plate 3) and subsequent conflicts over nest material between neighbouring nesters and, additionally, during protection of young against harassment by neighbouring nesters. The posturing involved a lunge directed at the body of another bird, usually with the

bill slightly agape, and frequently resulted in fights where opponents grasped each other's bills and twisted their heads vigorously or made responding lunges.

Figure 10 presents the rates of occurrence of "aggressive lunging" at Birch Lake in 1977 from 10 May to 5 September. The counts were conducted in intensive 5-minute periods throughout the day in successive weeks and numbers of adults present were taken into consideration. Levels of aggressive social interaction, as measured by this technique were higher during the height of courtship in May and early June than throughout the rest of the season. No "aggressive lunges" were observed after 15 August in 1977. Defense of mates and nests by both male and female pair members contributed to the higher incidence of "aggressive lunging" during courtship when as many as 183 acts were observed in a single 5-minute period (17 May) in a courting flock containing 44 birds that subsequently established colony A.

Although no intensive counts of this activity were conducted in 1976, the incidence of "aggressive lunges" observed during casual observation declined to zero during August of that year. These observations suggest that conflicts among adults decrease after nesting territories are vacated when young leave the nests at approximately 3 weeks of age.

"Nest Indication or Maintenance Movements"

These behaviours were among several that were observed only at the nest site and entailed attentiveness to the condition of the nest or

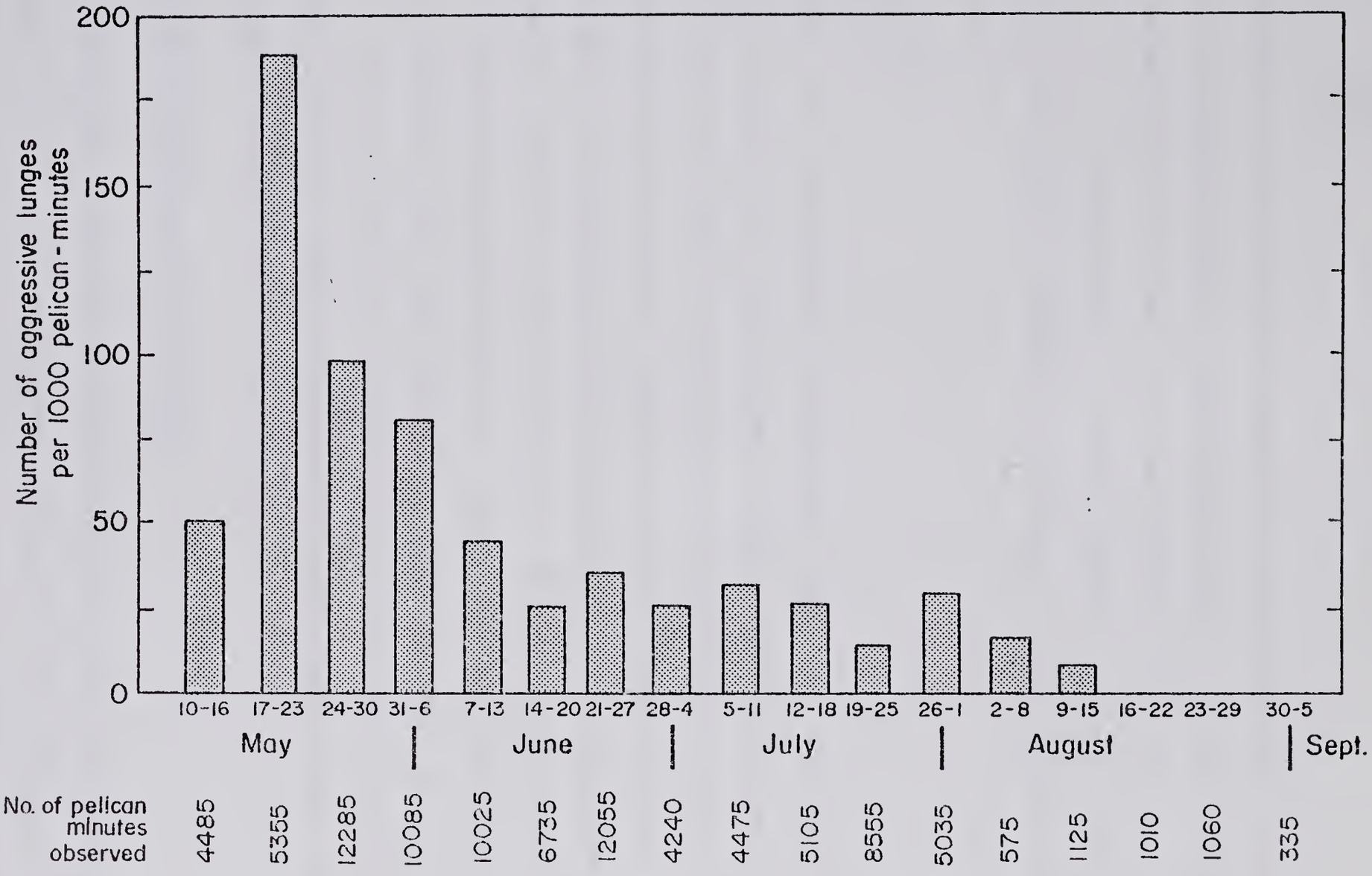


Figure 10. Rate of occurrence of "aggressive lunges" among adult White Pelicans at the rookery throughout the reproductive season in 1977.

its contents as well as comfort movements by the incubating or brooding birds including nest material gathering with the bill and pointing the bill downward toward the nest rim or nest contents (Plate 4). As breeding birds vacated their nests after young had left them in late July and early August, incidences of behaviours in this category ceased (Figure 7).

"Nest Roll"

White Pelicans performed this behaviour during nest construction and to shift the position of eggs or their incubating or brooding posture. During nest construction, while bracing the body with the wrists of the wings on the ground laterally, the feet kicked dirt out of the nest scrape posteriorly. The same posture was used to reposition the eggs under the body and to resettle or rise from the nest. As the young grew too large to fit comfortably beneath the parent in the nest, at approximately 2 weeks of age, the "nest roll" ceased to be observed. This occurred from mid- to late July (Figure 7). Similar postures have been described by Schreiber (1977) for tree-nesting Brown Pelicans. Schaller (1964) did not record this behaviour for White Pelicans.

Other Posture Adjustments on the Nest

This broad category of behaviours was used to describe settling motions on the nest and includes both rising off and settling onto the nest, shuffling the feet, readjusting the positions of the wings after periods of inactivity, and other changes in the resting posture. The

chronology of this category of behaviours (Figure 7) was similar to other nest related behaviours in that cessation occurred in late July as young left the nest.

"Egg Turning" or "Nibbling Young"

White Pelicans on nests rotated the eggs, which were incubated either under, between or on top of the webs of the feet, by either rolling them with the tip of the bill or by performing the "nest roll" using the feet and/or bill to move the eggs around. Frequently, the wings were slightly hunched or raised when the bill only was used and the bird rocked from side to side accommodating the new egg positions beneath its body.

Young were nibbled with the tip of the mandibles, in a manner similar to preening motions. "Nibbling of young" was noted in association with feeding of smaller young by their parents both at the nest and in pods. The behaviour probably functioned in attracting the attention of smaller young prior to feeding. Older young were not nibbled and when all young had reached the age of 4 to 5 weeks by mid-August, the behaviour ceased (Figure 7).

"Wing Flapping" (other than flight)

Wings were flapped to maintain balance during copulations, during bouts of preening as stretching movements and following bathing episodes to dry the feathers. "Wing flapping" was apparently contagious, particularly during situations of alertness and may have served as a

pre-flight signal. As a component of the nest relief, "wing flapping" was also accompanied by "bill pointing" behaviour as the relieved bird ran from the nest prior to departing for the foraging grounds. Knopf (1975a) also suggested that a similar behaviour during copulation, which he termed "wing flagging," may have functioned as an excitatory stimulus for paired birds during colony formation. At Birch Lake, the infrequent observation of wing flapping after August (Figure 7) may have been due to a decrease in its occurrence as a signal, copulatory stimulus or as part of nest relief activities. A breakdown of the functional components of "wing flapping" was not conducted.

The following behaviours exhibited by White Pelicans during this study were associated with the maintenance of feathers or appeared to be comfort movements. These behaviours tended to occur throughout the entire study period (Figure 7) with no discernible patterns except in a few cases associated with thermoregulation on warm days.

"Bill Plunging"

The "bill plunge" involved an oblique thrust of the head and neck forward into the water, often repeatedly, in the fashion of foraging. Bartholomew et al. (1953) demonstrated the effectiveness of pouch wetting in cooling the body temperatures of young White Pelicans. The behaviour was observed after parents had fed young and in those instances was probably used to cleanse the pouch of regurgitated materials or to assist in drinking; in this respect, "bill plunging" would not simply be a cooling mechanism.

"Gular Flutter"

"Gular fluttering" involved the rapid fluttering of the hyoid apparatus so that rippling waves were generated along the lateral pouch surface, serving to cool the birds (Bartholomew et al. 1953) through the mechanism of air flow over a vascularized evaporative surface. The partially open mouth promoted air flow. The behaviour was demonstrated by both adults and young on warm calm days when air temperatures were in excess of 20° C (6 of 8 instances). "Gular fluttering" by pelicans has been reported also by Schaller (1964), van Tets (1965), Brown and Urban (1969), Din and Eltringham (1974), Schreiber (1977) and Vestjens (1977).

"Bill Flick"

"Bill flick" motions involved the rapid opening and closing of the bill or jerking the bill rapidly with a quick twist of the head to one side. The behaviour was observed during preening bouts and after feeding young and appeared to function in dislodging feathers or regurgitated food from the bill and pouch.

"Pouch Shake"

With the neck outstretched and the bill pointing slightly downward, the pelican rapidly moved the head up and down so that the pouch flapped audibly. This behaviour appeared to be a means of cleansing the pouch and was observed after parents fed their young and during preening bouts. Although there were no visible indications of infestations of pouch lice

(Piagetiella peralis) in the pelicans at Birch Lake, pouch shaking could have been employed to dislodge these parasites. Infestations of this parasite have been observed elsewhere in White Pelicans (Greichus, Greichus and Call 1976). "Pouch shaking" was regularly observed throughout the entire study period.

"Head Shake"

"Head shaking" was observed at the termination of the "feather ruffle" described below, or as a separate, complete motion by itself. Movements involved the head being shaken from side to side with the neck stretched out in front of the body. The behaviour was observed after bathing and rainfalls, suggesting that it served to dry the feathers of the head and neck.

"Feather Ruffle"

Ruffling of the feathers followed bathing and rain-showers. With the feathers erected, the bird first began the sequence by "waggling the tail" from side to side several times, shook the whole body, then frequently the head and neck as well. The activity apparently helped dry or separate the feathers preparatory to preening.

"Bill Throw"

In this posture the bird moved the bill upward with the neck erect and spread the flexible rami of the lower mandible apart, creating an obovate expanse of pouch skin when viewed anteriorly. The behaviour

may have assisted in readjusting the glottis after exposing it (see below) and additionally to emphasize the presence of the bird as a "self-advertising" display. Schaller (1964) attributed a self-advertising function to a very similar behaviour which he called the "pouch spread." Functionally similar postures with various nomenclatures have been described for the Pink-backed Pelican (Burke and Brown 1970), and the Brown Pelican (Schreiber 1977).

The more regularly observed occurrence of this behaviour during the earlier part of the season (Figure 7) at Birch Lake indicated that the "bill throw" had some function in social communication but the basis for such an explanation was not clear.

"Neck and/or Wing Stretch"

With the wrists of the wings touching above the body, the neck was stretched low and forward, horizontal to the ground, with the bill pointing slightly upward as a result of a slight neck bending just posterior to the head.

Components of this motion, with either the wings above the body or the neck outstretched were observed as discrete actions themselves. A comfort function of stretching was attributed to the behaviour.

"Leg and/or Wing Stretch"

This comfort movement involved the stretching of one wing laterally and caudally while one leg was raised and similarly stretched on the same side. The neck sometimes extended forward for balance. Both the wing and leg stretching motions were observed as discrete postures.

"Yawn"

The lower mandible was slowly lowered with little or no lateral pouch expansion by the rami, then rapidly closed accompanied by an upward motion of the head. This comfort behaviour was observed only sporadically during the study (Figure 7).

"Glottis Exposure"

This behaviour derives its name from a similar activity described for Brown Pelicans (Schreiber 1977) and appears to involve the same motions described as a "pouch stretch" for White Pelicans (Schaller 1964) and Australian Pelicans (Vestjens 1977). The pouch was everted, exposing the anteriorly located glottal structures, by pushing the pouch over the upper breast. The rami of the lower mandible were flexed laterally with the head tucked back between the hunched wings.

"Neck or Head Scratch"

To maintain balance during scratching, birds crouched slightly with the weight resting on one foot. The wing on the side opposite the foot used to scratch was slightly lowered as the neck was bowed toward the rear. The scratching foot was slowly raised and brought forward, the scratching motion being effected with several rapid strokes of the nails across the base of the pouch, sides or back of the head and upper neck.

"Bathing"

"Bathing" served to both clean the feathers and cool the birds (Bartholomew et al. 1953) and appeared to be similar to motions employed

by other aquatic waterfowl. Feather erection, beating the slightly opened wings on water, "bill plunging" and rubbing the neck over the back of the wings and sides of the body were activities that were associated with "bathing" when birds were in the water. "Bathing" was frequently performed by several birds at once, particularly during the flock activities of courtship and post-nest relief preening and exercise although it was observed throughout most of the study period (Figure 7).

In 1976, 73 percent of 194 "bathings" occurred between 1400 and 1800. In 1977, during the same daily time period, 75 percent of 270 cases of "bathing" occurred. The predominance of "bathing" during the warmest period of the day suggests that "bathing" may in fact have functioned as a thermoregulatory behaviour in addition to maintaining feather condition. Observation bias due to more frequent sampling during the 4-hour period considered was minimal as only 21 percent and 25 percent of the total observation time was allotted to this period in 1976 and 1977 respectively.

The pelicans usually "bathed" in shallow water near the eastern tip of the island where the water was free from Water Smartweed; an adjacent area free of nesting birds and vegetation provided space to preen after "bathing." Over both years, 54 percent of 358 "bathings" of adults where location was recorded occurred along the weed-free east or southeast shores of the island.

"Preening"

"Preening" was defined as any maintenance of the feathers using the bill to manipulate the feathers of the bird (Plate 4). Feather maintenance

occupied much of the birds' waking hours when they were at the rookery, particularly when they were loafing away from the main nesting areas on the island. Both incubating and brooding birds "preened" for less time than loafing birds (Table 2), suggesting that this activity was more predominant during intervals when birds were not occupied with nesting duties. Loafing birds, in fact, had either recently arrived at the rookery to relieve mates on nests or to feed their young, or had been relieved by mates and were preparing to leave the rookery, presumably to forage.

"Sleeping or Resting"

White Pelicans rested with their eyes either open or shut. The sleeping posture involved tucking the bill over the back between and under the feathers of the wings while standing or squatting (Plate 3). Rest postures (Plate 2) were likewise assumed while standing or squatting but the bill either rested on or to one side of the breast, and often the tip touched the ground.

White Pelicans slept or rested for a large proportion of the time they were at the island, particularly when incubating (Table 2). Presumably, brooding birds slept or rested less because they were preoccupied with their young. Loafing birds again were significantly more active than incubators, as assessed by the proportional amount of time spent preening (Table 2).

From the results of Table 2, it was evident that the activities of preening and sleeping or resting occupied much of the pelicans' time while at the rookery, at least after the courtship phase. No intensive

Table 2. Comparison of the preening and resting times (minutes per 10 pelican-minute period) for incubating, brooding and loafing adult White Pelicans.[a]

Activity	Incubating			Brooding			Loafing		
	N	$\bar{X}$	Range	N	$\bar{X}$	Range	N	$\bar{X}$	Range
Preening	70	1.7	0.0-9.6	36	1.8	0.0-9.8	108	4.1[b]	0.0-10.0
Resting or Sleeping	70	7.1[c]	0.0-10.0	36	5.5[d]	0.0-10.0	121	4.2	0.0-10.0

[a]Symbols: N = Number of 10-minute observation periods; $\bar{X}$ = mean (in minutes).

[b]Loafing birds tended to preen more than either incubating or brooding birds ($p<.05$; Mann-Whitney test).

[c]Incubating birds tended to rest or sleep more than either brooding or loafing birds ($p<.05$; Mann-Whitney test).

[d]Brooding birds tended to rest or sleep more than loafing birds ($p<.05$; Mann-Whitney test).

10-minute period observations of courting individuals were conducted but courting activities seemed to occupy most of their time during the courtship phase.

"Head up Alert"

Attentiveness of adult pelicans to potential encroachments upon the rookery by people, other birds or mammals and aircraft was indicated by the assumption of the "head up alert" posture. The posture involved the upward craning of the neck while the birds either gazed at the source of disturbance or alternately looked from one side to the other. The posture was observed in both sitting and standing birds and was followed by movement away from the source of disturbance, either flying or running depending, apparently, on the degree of arousal. Birds at the rookery were always wary of approaches of the researcher in a canoe at distances less than 300 m, and reacted with the "head up alert" when aircraft were nearby as well. Birds flushed in response to direct approaches by aircraft or people within the confines of the lakeshore although attempts were made to keep such disruptions to a minimum.

Occasionally, the "head up alert" posture was assumed by adults during the normal course of activities at the island, particularly during courtship. The interpretation of this posture as a "fear" response may not be valid considering its occurrence in the absence of apparent disturbances at or near the rookery. The posture did indicate, however, a heightened degree of awareness by the birds, whether they were responding to the activities of their neighbours, other species of birds or other disturbances, Figure 7 demonstrates the occurrence of this behaviour throughout the entire study period in 1977.

All behaviours that were performed by the birds during incubating or brooding were counted during the intensive 10-minute observation of those individuals. Additionally, similar observations of loafing individuals throughout the study period yielded counts of behaviours demonstrated by that group (Table 3). These data allowed a comparison of the relative rates of occurrence for all behaviours previously described which were observed and additionally permitted some insight into the contribution of adults involved in these three categories of activity to the data presented in Figure 7. Unfortunately, few 10-minute observation periods were devoted to individual courting adults, due in part to their highly active nature and the difficulty in observing individuals in the milling courting flocks that were then prevalent. More general observations of specific behaviours have formed the basis for the preceding discussion of courtship behaviours.

The relatively infrequent performance of several of the maintenance and comfort behaviours has undoubtedly resulted in their sporadic detection as present in Figure 7. Maintenance and comfort behaviours collectively, however, were observed throughout the entire period of evaluation. Possibly, several of the maintenance and comfort behaviours served additionally as communicative behaviours, although the subtleties of their functions as such were not readily discernible. Schreiber (1977) has suggested that maintenance behaviours for Brown Pelicans have communication functions in context with concurrent surrounding events at the rookery; the contagious demonstrations of "bathing," "wing flapping," and "preening" by White Pelicans observed in this study may have indicated a degree of flock cohesion and thus communication.

Table 3. The frequency of occurrence (per 1000 pelican-minutes) of activities displayed by incubating, brooding and loafing adults at the Birch Lake rookery in 1977.[a]

Activity Category	Incubating	Brooding	Loafing
Mount young	0	0	1
Yawn threat	34	36	15
Aggressive lunges	144	58	44
Nest indication or nest maintenance movements	521	681	7
Nest roll	40	8	0
Other posture adjustments on nest	275	411	0
Egg turn	10	0	0
Nibble young	0	138	1
Feed young	0	36	1
Wing flap (other than flight)	7	3	15
Gular flutter	1	3	0
Bill plunge	0	0	2
Bill flick	128	926	40
Pouch shake	44	31	42
Head shake	10	0	4
Feather ruffle	3	0	40
Bill throw	1	0	6
Neck and/or wing stretch	1	3	13
Leg and/or wing stretch	1	6	
Yawn	1	3	2
Tail waggle	0	0	7
Glottis exposure	0	0	8
Neck or head scratch	9	17	41
Bathing	0	0	1
Head up alert	9	6	18
Grunt	6	0	0
Upright	7	0	2

[a]Frequencies were compiled from the following number of 10-minute observations of individuals: Incubating - from 63 to 70; Brooding - from 34 to 36; Loafing - 91.

Functional Aspects of Daily Movement Patterns

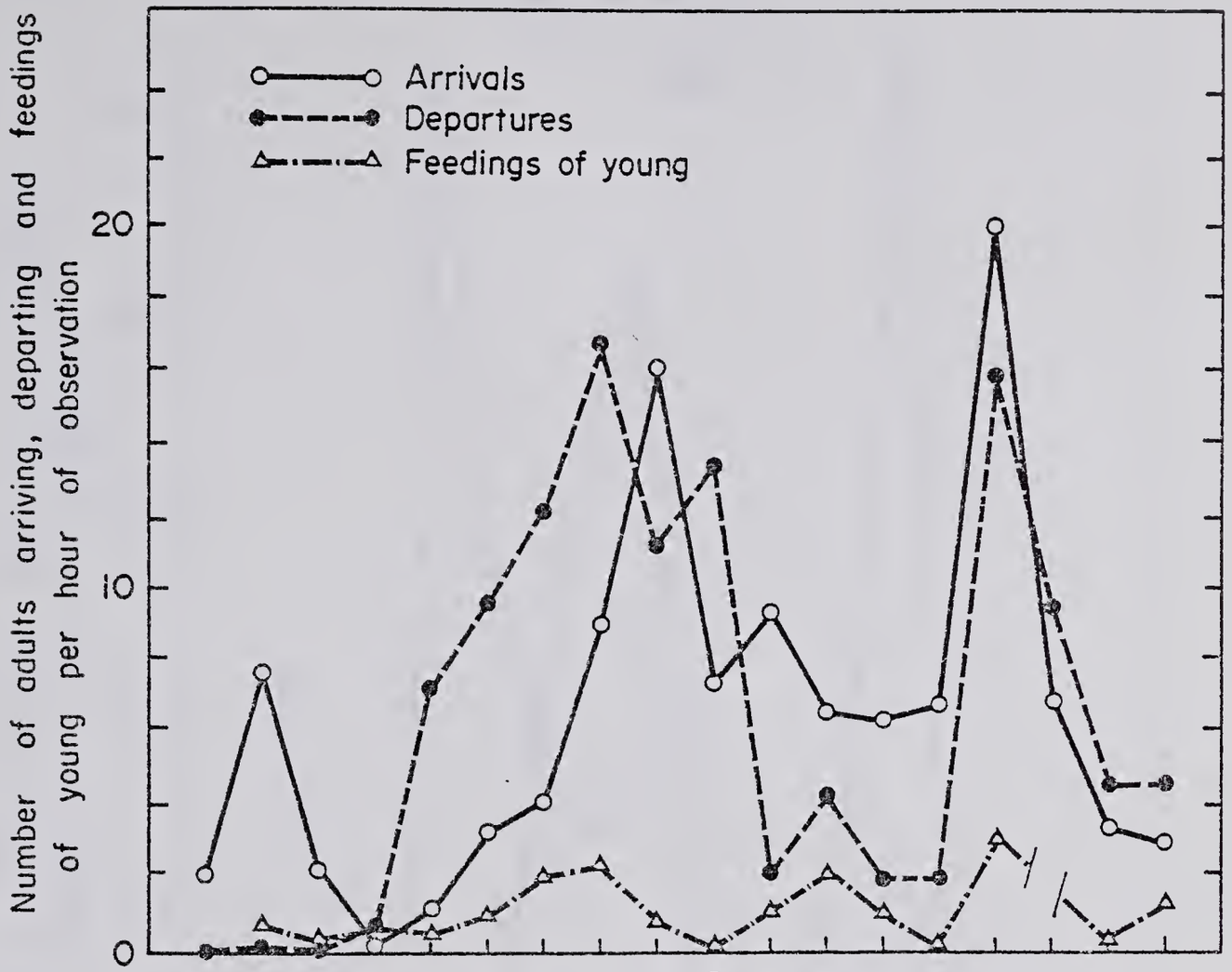
There has been some suggestion in the literature (Schaller 1964; Brown and Urban 1969; Burke and Brown 1970) that pronounced daily patterns of movement to and from pelican rookeries are associated with foraging flights to areas surrounding the rookery. Schreiber (1977) could find no regular pattern for the Brown Pelican colony he studied in Florida, however.

Schaller (1964) stated that midday movements were pronounced for White Pelicans at the Molly Islands rookery in Yellowstone Lake, Wyoming, particularly after the period when young were from 1 to 2 months old, but he noted some variability in the timing of such movements both before and after the period. Brown and Urban (1969) stated that movements of adult Great White Pelicans were most frequent from 1000 to 1600 each day. Pink-backed Pelicans at Lake Victoria, Kenya, apparently delivered fish daily to their nests between 0900 and 1300 (Burke and Brown 1970).

The literature suggested the use of midday thermals by pelicans to depart for and return from distant foraging areas. The consistent observation of soaring flocks, both departing from and arriving at the Birch Lake rookery at great altitude, suggests that this mode of flight was also employed by White Pelicans there. Further demonstration of the effect of weather on foraging movements was provided in August 1977 when cool, wet and windy weather was associated with more intensive local foraging at Birch Lake. Nocturnal foraging by White Pelicans (Hall 1925; Schaller 1964) has been reported although the effect on timing of movements from and toward the rookery has not been considered.

At Birch Lake, prior to the cessation of brooding of young in 1977, an early morning ingress of adults was observed from 0500 to 0600 (Figure 11). These adults were probably arriving from nearby lakes within 10 km of Birch Lake as overnight sightings of pelicans at these lakes were reported during this time (personal communication from Mr. Steve McGovern, AOSERP aquatic furbearer study technician, Fort McMurray, Alberta). An early morning influx was also observed after the cessation of brooding in both 1976 and 1977 from 0600 to 0700 and 0500 to 0600 respectively (Figures 12 and 13) and indicated continued use of nearby lakes at those times as well.

Considerable variability of arrivals and departures was observed throughout the day at different times during the reproductive season (Figures 11, 12 and 13) although movements were most pronounced during the midday and evening hours. No consistent pattern was demonstrated for the rates of arrivals or departures for the daily periods after cessation of continuous brooding from 1976 to 1977; however, the pattern for arrivals and departures in 1977 for the period while young were still being brooded was comparable to 1976 data for the period following cessation of continuous brooding. In this respect, it therefore appeared that the rate of egress and ingress of adults at the Birch Lake rookery was dependent on factors other than the stage of the reproductive season when counts were made. Other factors which could have been involved were differences in the scheduling of foraging flights to and from the waterbodies at various distances from the rookery and the fact that at the rookery there were always birds at different phases of the reproductive cycle at any given moment, a consideration inadequately revealed by



Time day	0400-0500	0500-0600	0600-0700	0700-0800	0800-0900	0900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	1800-1900	1900-2000	2000-2100	2100-2200
Hours observed for:																		
Arrivals & departures	2	7	17	11	8	9	33	26	12	8	16	20	13	10	5	6	17	11
Feedings	0	2	4	4	2	5	8	7	6	4	3	4	5	5	1	0	4	3

Figure 11. Daily pattern of arrivals and departures of adults and feedings of young prior to the onset of cessation of brooding at the Birch Lake rookery in 1977.

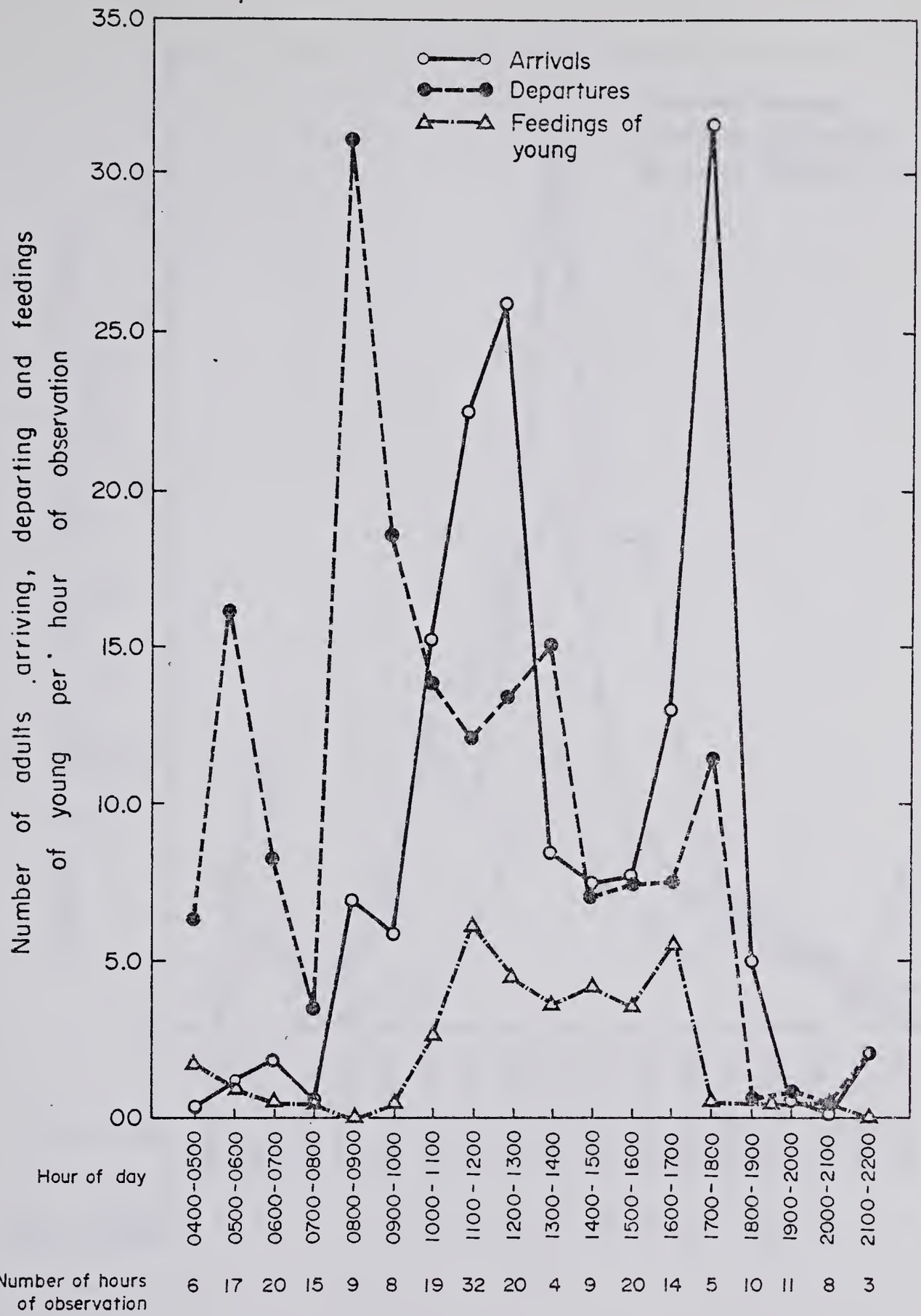


Figure 12. Daily pattern of arrivals and departures of adults and feedings of young after the onset of cessation of brooding at the Birch Lake rookery in 1976.

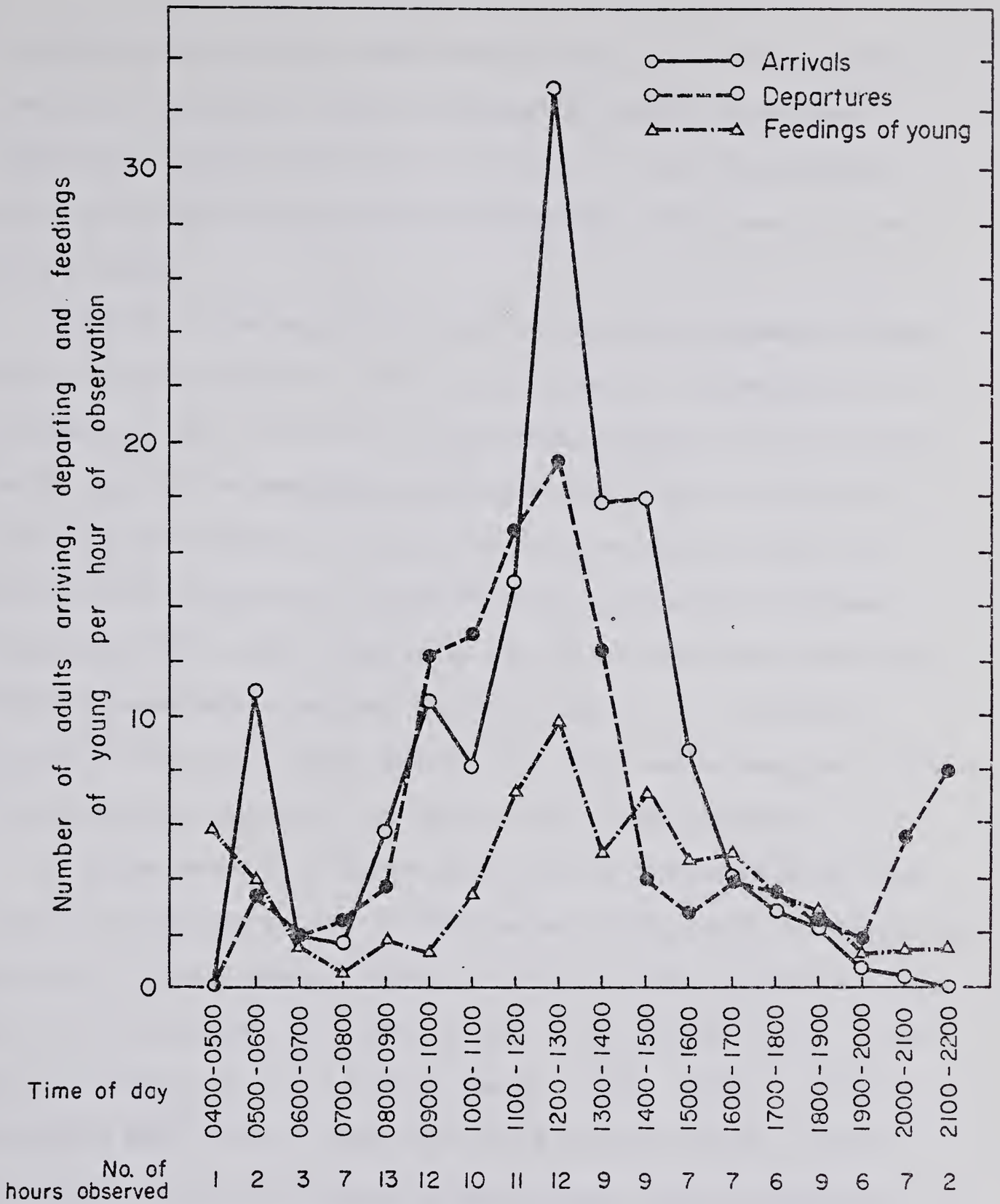


Figure 13. Daily pattern of arrivals and departures of adults and feedings of young after the onset of cessation of brooding at the Birch Lake rookery in 1977.

a simple analysis of dates when brooding first ceased. The foraging schedule did apparently change throughout the season, as has been suggested by Schalier (1964) but the results of techniques employed during this study did not reveal any consistent pattern over the two years of study.

The rate of feeding of young appeared to be only somewhat related to the rate of arrivals of adults at the rookery. A determination of the number of daily feedings given the young throughout their dependent period could not be determined accurately. Early morning feeding of some young was followed by a period of relative feeding inactivity. During the hours observed, most feedings occurred during the midday period from 1000 to 1800 (Figures 12 and 13) although this pattern was less pronounced when young were smaller (Figure 11). It appeared, similar to Schaller's (1964) observations, that smaller young were given several feedings throughout the day by their brooding parents.

A random sample of 1,105 arriving birds in 1976 revealed only 106 single bird arrivals but 999 in 128 separate flocks. Mean arriving flock size was 7.8 birds (range: 2-64). In 1977, of 2,650 observed arrivals, only 157 were singles, and 2,493 arrived in 327 separate flocks. Mean arriving flock size was 7.6 birds (range: 2-79). Schaller (1964) reported a mean arriving flock size of 4.8 pelicans based on 4,326 observed arrivals at the larger Yellowstone Lake rookery composed of approximately 300 breeding pairs.

At Birch Lake, a typical pattern of departure involved one or more birds leaving the rookery to soar over the shores of the lake where they were joined by others from the rookery. The resulting flock then flew

off, presumably to the foraging areas. Mean departing flock size in 1976 was 10.7 birds (range: 2-28) based on 28 flock sightings. Mean departing flock size in 1977 was 6.3 birds (range: 2-85) based on 366 flock sightings. Schaller (1964) reported a mean departing flock size of only 2.8 birds from observations of 4,416 departures at Yellowstone Lake, Wyoming.

The slightly larger mean arriving and departing flock sizes in 1976 were possibly due to the larger number of breeding birds present in that year, although it could not be determined whether all arriving or departing birds were breeding. As the departing birds soared above the rookery before leaving, they were frequently joined by other adults from the rookery. This flocking may also have occurred when birds departed from the foraging areas toward the rookery, since the sizes of arriving and departing flocks were similar.

Fifty-seven percent of the birds departing from Birch Lake in 1977 headed north and northeast in the direction of the Ells River headwaters foraging areas. The south and southwest bearings toward the suspected foraging areas of Mink and Grew Lakes were taken by 28 percent of departing adults. These foraging areas were at distances varying from 30 to 69 km from the rookery.

Nest Relief Ceremony

Little information on relief frequencies was obtained during most of the incubation period. Pair members could not be distinguished unless they were together and size used as the criterion of identification. As the presupplemental moult progressed, each member of the pair acquired distinctive dark markings on the head and neck, making it possible to recognize individuals of some nesting pairs.

Nest reliefs occurred throughout the daily observation period from 0600 to 2200, although they were more frequent during the late morning, early afternoon and early evening (Figure 14). These peaks approximately coincided with increases in the numbers of arriving adults previously discussed (Figures 11, 12 and 13). When two reliefs were observed in 1 day, the second relief occurred in the early evening. Interruptions in the continuous observation of nests selected to monitor nest relief frequencies has made the following interpretations tentative only.

Twenty-nine consecutive nest-days (one nest observed for 1 day) were accumulated for incubating birds versus 58 consecutive nest-days for brooding birds at the 12 monitored nests. Hatching at two nests was observed over a period of 3 days at each nest. All 30 nest reliefs observed for incubating birds were on consecutive days. For brooding birds, four reliefs were less than 1 day apart, 45 were 1 day apart and four were from 1 to 2 days apart. During hatching, two reliefs occurred with a frequency of from 1 to 2 days, and only one relief occurred over a period of from 2 to 3 days. Some variability in the frequency of nest reliefs was thus apparent during and after hatching although reliefs on consecutive days accounted for 75 of the total of 88 reliefs observed at the 12 monitored nests. The time that adults were on the nest, therefore, did not appear to exceed 2 consecutive days during brooding and 1 day during incubation; however, a reluctance to leave the nest at hatching time was indicated with one bird observed on a nest for from 2 to 3 days during hatching.

Schaller (1964) cited a mean relief frequency of once every 2 days during incubation with a variation of 1 to 3 days. Schaller's (1964)

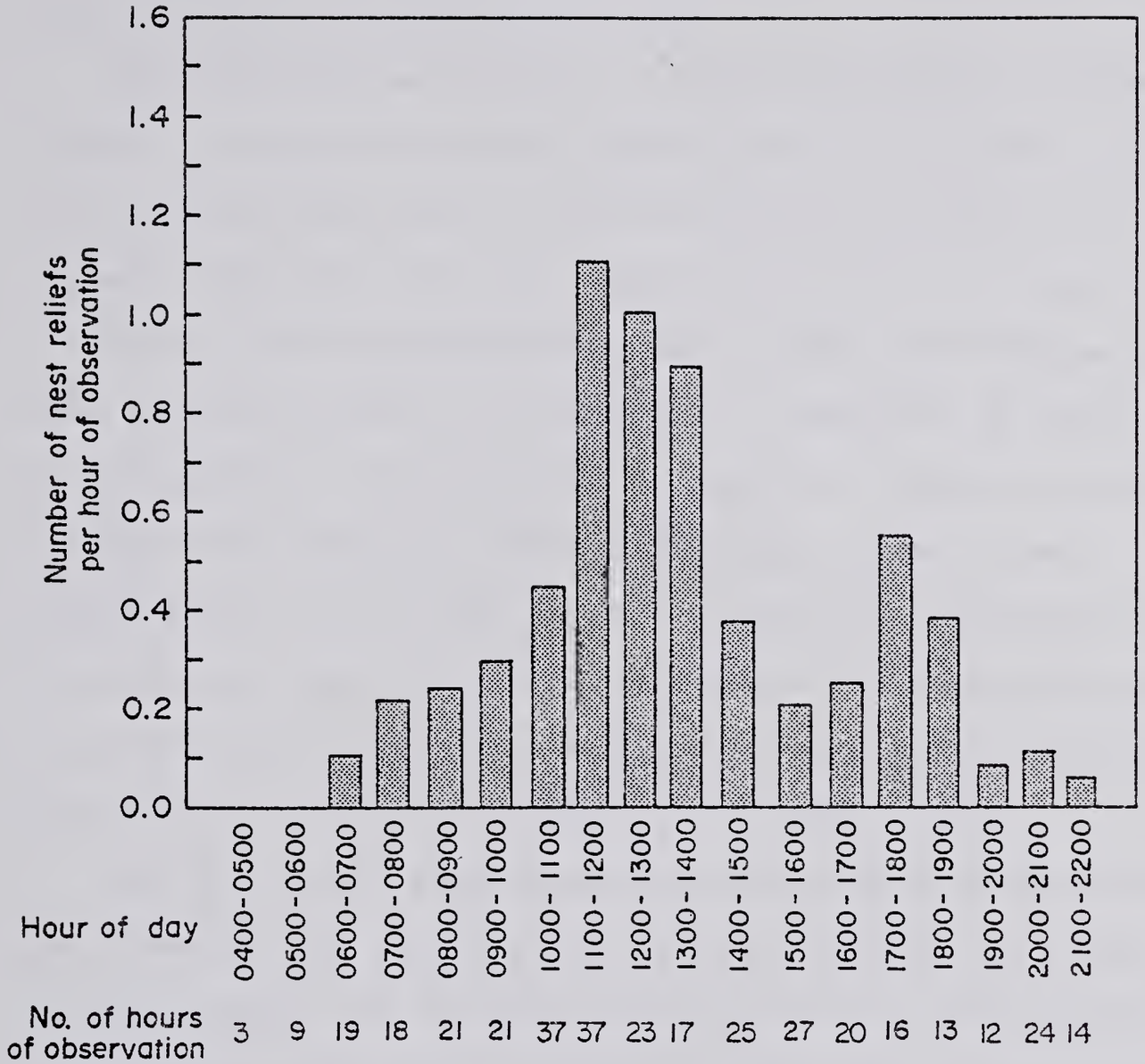


Figure 14. Frequency of occurrence of nest reliefs during different periods of the day in 1977.

observations of brooding birds revealed a relief frequency of "once a day, occasionally twice a day, and rarely once every two days." The results of this study appeared to be comparable only to Schaller's brooding data, since no variability was observed in the daily relief schedule during incubation at Birch Lake.

The exchange of nesting duties at Birch Lake involved a ceremony (Plate 4). Behaviours previously exhibited by pelicans during courtship and nesting building continued to be displayed during nest reliefs, including "uprights," "grunting," "head swaying," "bowing," and "nest indication or maintenance" motions. The time that the birds devoted to these activities varied, as did the apparent intensities of the ceremonies. In some instances, the nesting pelican vacated the nest after cursory "uprights" were exchanged, while in other cases the pair "bowed," presented nest material and performed "uprights" for several minutes, both before and after nest duties were exchanged. As the nesting season progressed, nest relief ceremonies became less intense and ceased as young left the nests at approximately 2 to 3 weeks of age.

Nest reliefs were timed from the arrival of the relieving pelican at the island until the departure from the nest of its mate and divided into two time periods: the first from the arrival of the relieving bird until the initiation of the relief ceremony; the second from the initiation of the ceremony until the bird on the nest had exchanged places with its mate (Tables 4 and 5). The results showed no differences in these two intervals of the relief for either the incubating or brooding pairs or male and female members of the pair. Schaller (1964) reported a mean passage of time of 8.4 minutes (standard deviation = 12.08 minutes)

Table 4. Comparison of the nest relief times for incubating and brooding adults in 1977.[a]

Relief Chronology	Relief Time (minutes)			
	Incubating		Brooding	
	Mean	S	Mean	S
From arrival of relieving bird to initiation of relief ceremony	3.83(11)[b]	3.07	7.45(9)[c]	9.62
From initiation of relief ceremony to completion of relief (one bird off nest and mate on nest).	0.52(23)	1.25	0.51(15)[c]	0.41

[a]Symbols: S = one standard deviation.

[b]Number in parentheses is sample size.

[c]Means are not significantly different from incubating birds as determined by t tests ($P>0.2$).

Table 5. Comparison of the nest relief times for male and female members of the pair in 1977.[a]

Relief Chronology	Relieving Time (minutes)			
	Males relieving		Females Relieving	
	Mean	S	Mean	S
From initiation to completion of relief ceremony (one bird off nest and mate on nest).	0.56(24)[b]	0.80	0.39(25)[c]	0.40

[a]Symbols: S = one standard deviation

[b]Number in parentheses is sample size

[c]Mean is not significantly different from male birds as determined by t tests ($p>0.2$).

from the time a bird arrived at the nest until it had settled on the nest for 160 reliefs observed. This appeared to be longer than observed in this study although the Birch Lake sample sizes were much smaller. Schaller did not specify whether the reliefs he observed were for incubating or brooding birds; the results from Table 4 demonstrate a longer elapsed time for brooding reliefs than for incubating reliefs (although not significantly so). If Schaller's nest reliefs were, in fact, of brooding birds, then conceivably the results of this study were comparable.

Physical and Behavioural Development of the Young

Development of the young appeared to follow the chronologies described by Schaller (1964) with a few exceptions. Schaller (1964) reported that adult pelicans began to leave their young unattended as they approached 3 weeks of age and these young subsequently began to associate with young from neighbouring nests, returning to their nests to feed when their parents returned. This pattern applied at Birch Lake in 1977 but in 1976, young were approximately 1 week older before they were left unattended.

Young began to wade and swim when they reached the age of 5 to 6 weeks; bathing first occurred at 5 to 7 weeks of age. Strait (1973) reported that White Pelican young did not enter the water at 7 to 8 weeks of age unless they were disturbed. Schaller (1964) reports that the young he observed were swimming, when disturbed, at 3 to 4 weeks of age.

At Birch Lake, in 1977, the young ran and flapped into the wind when they were 6 to 7 weeks old and at the age of 8 to 9 weeks they made occasional flights of a few metres distance. Schaller (1964) described a brief flight for a 9 to 10 week old young White Pelican, but first flights at Birch Lake in 1976 were not recorded until the young were 11 weeks old. In 1977, 10 week old young could fly quite well and, in one instance, a young of this age actually soared. In 1976, the young pelicans were 2 weeks older when they began these flights. Schaller (1964) did not specify when young at the Molly Islands began these soaring flights but he implied that it was after they had reached 10 weeks of age. Knopf (1975a) reported that young at Gunnison Island were flying at 12 to 13 weeks of age.

Compared with young pelicans observed at Birch Lake in 1976 and at other localities in previous years, the Birch Lake young appeared to mature at a faster rate in 1977. Perhaps a more abundant food supply or warmer temperatures resulted in the precocity of the 1977 cohort. Although I could find no documentation substantiating these speculations, Schreiber (1976) suggested that availability of food, temperature and the additional factors of foraging efficiency of the adults, asynchronous hatching of nest-mates and perhaps the sex of the nestlings influenced the rate of growth of individual Brown Pelican young; these factors might affect the rate of maturation of White Pelican young as well. Additionally, the flooding of the rookery in August 1976 necessitated a move by the young to the northwest shore of Birch Lake although it was observed that adults fed young only at the island after the move. The voyage of approximately 0.5 km from the shore to the few exposed points

of the island necessitated an energy output by the young which may have affected their rate of growth substantially. Young did loaf occasionally at the northwest shore again in 1977 during the day but most roosted at the island overnight and were fed there.

The young began to form pods or clusters (Plate 4) as the adults ceased continual brooding; these pods persisted throughout the summer until the young were able to fly. Pods were flexible entities, forming and disbanding with a variety of circumstances, and were composed of varying ages and numbers of young. Clustering appeared to serve two functions which were not necessarily mutually exclusive, providing warmth and protection.

In 1977, chicks began to cluster when 2 to 3 weeks old. These first pods were very small, consisting of from two to five young of the same age from neighbouring nests. When an adult left its chick unattended, the chick would crawl or stagger to the nearest nest and huddle with the chick(s) there, if tolerated by the brooding adult. Frequently, however, brooding adults pecked at strange chicks and did not allow them to huddle beneath them. In these instances, the chicks would join nearby pods of young. Young in the earliest formed pods returned to their nests to be fed by their parents.

Young less than 3 weeks of age cannot efficiently thermoregulate (Bartholomew et al. 1953; Schaller 1964; Knopf 1975a). It therefore appeared that, in the overnight period at least, these early pods conserved the body heat of the young. The pods increased in the number of young they contained as later hatched young began to join them. Typically, young began to gradually huddle in several pods as evening

approached and on cool days, the groups becoming gradually more diffuse during the midday period. When the chicks reached 6 or 7 weeks of age, they no longer associated in these types of pods and roosted alone in the overnight period.

Young pelicans formed a large single pod in response to the nearby presence of potential avian predators including Bald Eagles (Haliaeetus leucocephalus), Goshawks (Accipiter gentilis) and Common Ravens (Corvus corax). They responded similarly to aircraft flying at varying altitudes near the rookery. Even approaches to the stationary blind after I had made previous visits to the rookery in August of both years appeared to alarm the young as well, causing them even to vacate the rookery and swim to the loafing area on the northwest shore.

The mutual awareness of the young pelicans was evident in pods. Pods frequently formed around several young engaged in one activity. These pods were small, and usually consisted of similarly aged young and appeared to form and disband spontaneously. As an example, one young observed flapping its wings was joined by several nearby young which began to flap as well. The activity then ceased as quickly as it had begun. Demonstrations of precocial "bowing," nest material "juggling," "yawn threats" and group foraging were all observed for smaller young in pods at or near the rookery. It was possible that such behaviours represented a learning process which was enhanced by the social pod unit. Table 6 summarizes the observations of the physical and behavioural development of young White Pelicans at Birch Lake.

Table 6. Physical and behavioural development of young White Pelicans at Birch Lake, northeastern Alberta

Age of Young (weeks)	Physical Description and Behaviour
0-1	Young are naked, pink in colour.
1-2	Acquisition of white down. Young can lift head to feed. Legs and mandibles gray.
2-3	Down covering prominent. Mobility evident, pods begin to form. Begging behaviour pronounced with vocalizations audible at 300 meters. Adults no longer brood continuously.
3-4	Down covering appears gray and dirty. Young can walk. Sheaths of retrices and remiges are visible.
4-5	Young now walk well. Begin to spend more time away from pod unit.
5-6	First young observed swimming and bathing. Primary feathers have erupted approximately 5-10[a] cm from sheaths. Wing coverts still downy in appearance.
6-7	Wing primaries erupted approximately 15 cm from the sheaths. Young begin to roost overnight away from pods.
8-9	Wing primaries erupted approximately 25-30 cm. Tertial feather growth incomplete. Young make first brief flights. Mandibles and feet now yellowish in appearance.
9-10	Young now make flights within confines of lakeshore with occasional soaring.
10-11	Tertial feather growth almost complete. Young fly confidently beyond the confines of the lakeshore.
12-14	Young begin to disperse from the home lake. Migration probably follows immediately.

[a]Measurements not made. Estimates based on visual inspection from observation posts using spotting scopes.

SUMMARY AND CONCLUSIONS

White Pelican rookeries in the Birch Mountains area of northeastern Alberta were located on small, gradually sloping islands in permanent waterbodies. In both 1976 and 1977, the birds nested on a small barren island in Birch Lake, located approximately 10 km south of Namur Lake. An estimated 140 pairs nested in 1976 and 70 pairs in 1977. Available records indicated the use of other rookeries located at Namur Lake and Big Island Lake in years prior to 1976; however, neither location was occupied by nesting White Pelicans during the course of this study.

White Pelicans arrived in late April in advance of spring breakup and were concentrated on flowing open water areas until warmer weather in early May freed Birch Lake of ice. The birds then commenced courtship actitivies at the rookery. Nest construction and defense against encroaching pelicans and gulls occurred in May and early June. Eggs were laid immediately after the pair had defended the nest site and had begun nest construction. Hatching occurred primarily during June. The mode of development of the young was altricial and young required approximately 12 to 14 weeks before becoming independent of their parents. Young first flew in mid-August at the age of approximately 8 weeks and appeared to begin migration after the attainment of flying proficiency at 12 to 14 weeks of age. Most birds, both young and adults, departed in September.

White Pelican adults arrived at the summer grounds in the nuptial (breeding) plumage which was retained until the onset of incubation, then a presupplemental moult of the head and neck regions replaced the yellow or white nuptial crest plumes with shorter darker feathers and the bill

horn was shed. Males, recognized by larger size and longer bills, appeared to outnumber females in the breeding population. Individual pair members were recognizable by characteristic combinations of plumage, size and bill length after the onset of incubation when they were both at the nest site.

White Pelicans bred in synchronous groups called colonies at a rookery site. The colonies were spatially discrete with varying degrees of temporal asynchrony among them (i.e., some were more synchronous than others). At Birch Lake, pairs displayed in the midst of courting flock assemblages and established nests there. Colonies formed over a period of 12 to 29 days although individual colonies were established over a period of from 7 to 14 days. Only a few later nests were appended to existing colonies up to 19 days after the last colonies had formed. Four colonies were established in 1976 and five in 1977 at Birch Lake.

The first formed colonies were the largest in both years and were established on the higher central areas of the island. The probable factors limiting colony sizes were the number of courting females and the number of courting flocks that were simultaneously active. After the establishment of nests within them, colonies apparently lost their attractiveness to courting birds; new colonies were subsequently formed from courting flocks composed of these birds.

One result of the asynchrony among colonies was staggered hatching at the rookery; it was possible to observe both incubating and brooding adults at the same time. Young hatched within colonies were approximately the same ages and formed pods when they left their nests at 2 to 3

weeks of age. Those chicks which hatched later in other colonies joined existing pods resulting in the formation of one or more larger pods.

During the incubation and brooding phases, only one member of the pair tended the nest contents at any given time. The other pair member was free to fly to distant foraging waters as far as 69 km from the rookery. Adults returned from the foraging areas primarily during the daylight hours to either relieve mates on nests or to feed their young. Adults ceased continuous brooding of their young approximately 3 weeks after eggs had hatched and brooded intermittently until their young were about 4 weeks old. Thereafter, both adults were free to forage, leaving their young in the pods during the day when they were away foraging.

Another result of the study was the establishment of a behaviour chronology "profile" for this rookery of breeding White Pelicans, dating from their arrival in spring to their departure in the fall. The majority of observed behaviours was not restricted to any particular phase of the reproductive cycle and this was especially true of maintenance and comfort behaviours. Those behaviours confined to earlier periods of the reproductive cycle were assumed to function in the synchronous pairing of sexually mature birds (in the breeding plumage) and appeared to be social and communicative in nature. Courtship behaviour possibly transmitted information about the identity, sex and readiness to mate of potential pair members, and involved group display in courting flock assemblages. Heightened aggression during the courtship phase was associated with apparent defense of potential female pair members by

males against other males. "Aggressive lunging" also characterized the defense of the nest itself as long as the pair was associated with a nest.

Successful copulation between pair members consummated the pairing process in the vicinity of established nest sites. Mutual stimulation of birds in the same breeding condition (as indicated by nuptial plumages) was apparently accomplished through the mechanism of social facilitation during courtship and may be required for the successful establishment of a nest by a pair (Knopf 1975a).

Pair members continued to identify each other by display at the nest during the nest relief ceremonies of incubation and brooding, but displays declined in frequency thereafter as paired birds infrequently met at the nest.

It appears that synchronized breeding in White Pelicans has several important adaptive significances which could be further studied. Densely nesting aggregations of birds which actively defend their nests against encroachment by neighbouring pelicans or other birds provide protection of nest contents against trampling or predation. At Birch Lake, White Pelicans on nests were aggressive toward California Gulls which nested in association with the colonies; dense aggregations of aggressive pelicans thus prevented the free movement of gulls through the colonies and doubtlessly prevented the predation of eggs or small young. Disturbances which force pelicans from their nests would allow gulls to move freely through the rookery and could result in greater losses of eggs and young.

The mechanism of synchronization of the reproductive effort may also have important implications if White Pelicans use widely scattered but abundant fish supplies. It appeared that foraging birds travelled to and from the foraging areas in flocks, a situation viewed as enhancing the food searching capabilities of individuals. Optimum nutrition for the young would be realized by synchronized breeding and exploitation of local food abundance by their foraging parents. Feeding in flocks would not be as effective and might present a liability if the foraging birds were dependent on a single geographic foraging area: failure of that resource would increase starvation of the greatest number of young. Daily travel to widely scattered foraging areas within a 69 km radius of the rookery did not appear to exceed the capabilities of the adults which used thermals to assist their flight.

The behaviours which synchronize mating appear to be important in the successful execution of colonial nesting in White Pelicans, particularly in temperate latitudes where there is a limited time available for the completion of rearing altricial young. By arriving at the earliest possible time, the breeding population increases the probability of successfully raising young in years when an early autumn freeze-up would curtail foraging.

Further study of the specific causes of young mortality over several years could help determine whether starvation of young is higher in years when foraging is curtailed by ice in the autumn or breeding delayed by a late spring breakup. Intensive study of the diet of White Pelicans through the collection of regurgitations of the young (Hall

1925) in conjunction with sampling of foraging areas for food abundance and availability could give more insight into the relationships between White Pelicans' diet and their use of different foraging areas.

More specifically related to the study objectives as outlined, the present study has accomplished the following:

1. The chronology of reproductive events for a rookery of White Pelicans breeding in northeastern Alberta has been determined.
2. Reproductive behaviour patterns have been identified and described. Documentation of these patterns for this species has contributed much new information.
3. Physical and behavioural changes of adults and young throughout the spring and summer months have been described.
4. Consistent daily movement patterns, presumably associated with foraging, were not demonstrated for White Pelicans from year to year although numbers of midday movements were generally higher.
5. By comparison with the descriptions provided by other researchers, the behavioural similarities and dissimilarities of White Pelicans to other pelican species have been determined. More work is yet needed, however, to delineate behaviour homologies.

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APPENDIX

APPENDIX I

Long Term Climatic Data from Fort McMurray.[a]

Location	
Lat.	57°
Long.	111°
Elevation	360 m asl
Mean Annual Temp.	-0.6°C
January average min. temp.	-26.7°C
July average max. temp.	24.4°C
Average date mean temp. rises to 5.6°C	29 April
Average date mean temp. falls to 5.6°C	3 October
Average number of days mean temp. 5.6°C and above	157
Mean May to Sept.	12.8°C
Mean rainfall May to Sept.	28 cm
Mean annual precipitation	42 cm

[a]Source: adapted from Rowe (1972).

APPENDIX II

Sunrise - sunset data:[a] Bitumount area.[b]

Month	Sunrise		Sunset		Hours of daylight	
	earliest	latest	earliest	latest	max.	min.
May	0339	0436	2011	2109	17.30	15.35
June	0328	0338	2111	2128	18.00	17.33
July	0334	0422	2044	2127	17.53	16.22
August	0424	0526	1927	2042	16.18	14.01
September	0528	0628	1804	1925	13.57	11.36

[a]For the period from May to September: mountain standard time.

[b]Source: Atmospheric Environment Service, Environment Canada.

APPENDIX III

Other aquatic avifauna observed at Birch Lake.

Common Name	Scientific Name	Status[a]
Common Loon	Gavia immer	b
Red-necked Grebe	Podiceps grisegena	b
Horned Grebe	Podiceps auritus	b
Eared Grebe	Podiceps nigricollis	b
Pied-billed Grebe	Podilymbus podiceps	b
Double-crested Cormorant	Phalacrocorax auritus	w
Great Blue Heron	Ardea herodias	r
American Bittern	Botaurus lentiginosus	r
Whistling Swan	Olor columbianus	m
Canada Goose	Branta canadensis	r
White-fronted Goose	Anser albifrons	m
Snow Goose	Chen caerulescens	m
Mallard	Anas platyrynchos	b
Gadwall	Anas strepera	r
Pintail	Anas acuta	b
Green-winged Teal	Anas crecca	b
Blue-winged Teal	Anas discors	b
American Widgeon	Anas americana	b
Northern Shoveler	Anas clypeata	b
Redhead	Aythya americana	r
Ring-necked Duck	Aythya collaris	r
Canvasback	Aythya valisineria	r
Greater Scaup	Aythya marila	m
Lesser Scaup	Aythya affinis	b
Common Goldeneye	Bucephala clangula	b
Bufflehead	Bucephala albeola	b
Old Squaw	Clangula hyemalis	m
White-winged Scoter	Melanitta deglandi	r
Surf Scoter	Melanitta perspicillata	r
Ruddy Duck	Oxyura jamaicensis	r
Hooded Merganser	Lophodytes cucullatus	w
Common Merganser	Mergus merganser	r
Red-breasted Merganser	Mergus serrator	r
Sora Rail	Porzana carolina	b
American Coot	Fulica americana	b
Wilson's Phalarope	Steganopus tricolor	r
California Gull	Larus californicus	b
Ring-billed Gull	Larus delawarensis	r
Franklin's Gull	Larus pipixcan	r
Bonaparte's Gull	Larus philidelphia	b
Common Tern	Sterna hirundo	r
Black Tern	Chlidonias niger	b
Belted Kingfisher	Megaceryle alcyon	b

[a] Symbols: b=breeds; w=wanderer; r=resident, breeding status unknown; m=migrant.

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